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(71) Applicant: MITSUBISHI DENKI KABUSHIKI KAISHA
Tokyo 100 (JP)

(72) Inventors:
- Nakamura, Keiji
  Chiyoda-ku, Tokyo 100 (JP)
- Shinoda, Masahisa
  Chiyoda-ku, Tokyo 100 (JP)
- Utakouji, Takeshi
  Chiyoda-ku, Tokyo 100 (JP)
- Watanabe, Norihiro
  Chiyoda-ku, Tokyo 100 (JP)
- Takeshita, Nobuo
  Chiyoda-ku, Tokyo 100 (JP)
- Kobachi, Hideaki
  Chiyoda-ku, Tokyo 100 (JP)
- Ogawa, Masaharu
  Chiyoda-ku, Tokyo 100 (JP)
- Yokoyama, Eiji
  Chiyoda-ku, Tokyo 100 (JP)
- Komawaki, Kouichi
  Chiyoda-ku, Tokyo 100 (JP)
- Kime, Kenjiro
  Chiyoda-ku, Tokyo 100 (JP)
- Yabe, Mitoru
  Chiyoda-ku, Tokyo 100 (JP)

(74) Representative: Burke, Steven David et al
R.G.C. Jenkins & Co.
26 Caxton Street
London SW1H 0RJ (GB)

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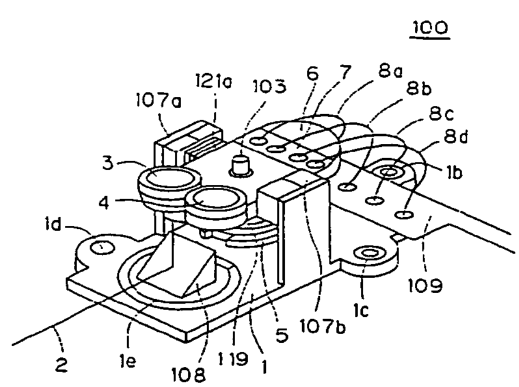
(54) Objective lens driving device and optical information recording/regenerating device

(57) The reference character 5 denotes a supporting shaft holding base, which holds the lower end of a supporting shaft 103 coated with fluororesin with a small frictional coefficient. The reference characters 107a and 107b are tracking magnets bipolar-magnetized in the right and left direction, which are fixed to a fixing base 1 by bonding. The character 108 denotes a mirror for reflecting a light beam 2 incident from the front in the vertical upward direction. The character 6 denotes a lens holder formed of a plastic material, or the like, with light weight and high stiffness, which holds objective lenses 3 and 4 corresponding to a plurality of optical information recording media with different substrate thicknesses and different recording densities at positions eccentrically displaced by almost equal distances from the supporting shaft 103.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to objective lens driving devices and optical information recording/regenerating devices, and particularly to an objective lens driving device and an optical information recording/regenerating device for applying recording or regenerating to a plurality of optical information recording media of different kinds with different substrate thicknesses, different recording sensitivities, etc. in a single optical information recording/regenerating device.

[0002] In this specification, the word 'regenerate' and derivations therefrom should be read as 'reproduce' and derivations therefrom.

Description of the Background Art

[0003] Optical information recording/regenerating devices have widely spread which optically record and regenerate information using a laser beam, such as a semiconductor laser beam, as a light source. In an optical information recording medium used in such a device, e.g., in a read-only compact disc, information is carved in the form of spiral unevenness at intervals of about 1.6 μm on a 1.2 mm thick polycarbonate substrate. The laser beam is applied onto the information surface through the 1.2mm thick polycarbonate substrate to detect information as a change in intensity of reflected light.

[0004] Generally, it is common that the laser beam is applied through a transparent substrate in the optical information recording/regenerating devices as described above, but optical information recording/regenerating media having substrate thicknesses and information track pitches different from those of the compact disc are appearing to achieve recording density higher than that of the compact disc. However, to regenerate such optical information recording media with different substrate thicknesses and track pitches with a conventional optical information recording/regenerating device has been extremely difficult or impossible.

[0005] This is due to the following facts: first, since the objective lens for condensing and applying the light beam onto the optical information recording medium is designed so that the aberration becomes the smallest for the thickness of the used substrate, large aberration occurs for a substrate with a different thickness and a light spot which is condensed enough to regenerate information is not formed, and second, the difference in track pitch means a difference in recording density of the optical information recording medium, so that recording and regeneration of information are difficult without using an objective lens dedicated for that recording density.

[0006] One method for solving this problem is to switch objective lenses to adapt to different optical information recording media. A conventional optical information recording/regenerating device, however, had an objective lens driving device which is finely movable for focus adjustment and tracking adjustment, but the objective lens driving device did not have a function of switching objective lenses adapted to the respective different optical information recording media.

<First Conventional Example of Optical Information Recording/Regenerating Device>

[0007] Fig.67 is a perspective view of a conventional objective lens driving device. In the figure, 2 is a light beam, which forms a light spot 201 with an objective lens 116. The objective lens 116 is attached to a lens holder 115 formed of a plastic material with small weight and high stiffness, and the lens holder 115 has a bearing 118 formed of an aluminum material, for example. A balancer 117 is also provided facing the objective lens 116. Furthermore, the lens holder 115 is equipped with a focusing coil 119 and tracking coils 121a and 121b. The lens holder 115 is held turnable and up-and-down movable by the bearing 118 and a shaft 103 provided on the fixed side, and the focusing coil 119 is disposed in a magnetic field formed by a focusing magnet 104 provided on the fixed side and focusing yokes 105a and 105b. The tracking coils 121a and 121b are disposed in a magnetic field formed by bipolar-magnetized magnets 107a and 107b (not shown but disposed in symmetrical positions) provided on the fixed side.

[0008] Fig.68 is a diagram showing an optical system in the conventional optical information recording/regenerating device. The light beam 2 emitted from a semiconductor laser passes through a diffraction grating 203, a half prism 204, a collimator lens 205 and directed at a sending up mirror 206 to impinge upon the objective lens 116 to form the light spot 201. The light spot is formed on the medium (not shown) and its reflected light reversely travels to pass through a focus sensor lens 207 due to the half prism 204 to be received at a photodetector 208. At the photodetector 208, the focusing error and the tracking error of the light spot 201 are detected as well as information signal on the medium (not shown), according to which feedback control is applied to the objective lens driving device.

[0009] In order to correct the focusing error of the light spot 201, desired current is applied to the focusing coil 119 to control the lens holder 115, and in turn, the objective lens 116 in the direction shown by the arrow C in the figure with the electromagnetic force obtained by the interaction with the magnetic field produced by the focusing magnet 104, thus providing control in the focusing direction.

[0010] In order to correct the tracking error of the light spot 201, a desired current is applied to the tracking coils 121a and 121b to turn the lens holder 115 around the

supporting shaft 103 in the direction shown by the arrow D in the figure with the electromagnetic force obtained by the interaction with the magnetic field produced by the tracking magnets 107a and 107b (not shown but disposed in symmetrical positions), thus providing control in the tracking direction of the objective lens 116.

[0011] Fig.69 is a diagram showing the relation between the optical information recording medium 202 and the objective lens 116 in the conventional optical information recording/regenerating device. The light beam 2 entering the objective lens 116 is condensed by the objective lens 116 and passed through the layer of the plastic substrate 204 to read the information pit 203. As the refractive index of the substrate 204 is different from that in the air, an objective lens 116 specialized for a determined thickness must be provided. The thickness (d1) of the substrate is 1.2 mm in the well-known CD (compact disc), and in order to adapt to an optical information recording medium with a substrate thickness 0.6 mm. another exclusively designed objective lens must be used.

[0012] The information pit 203 differs according to the recording density. In the CD, for example, the track pitch is about 1.6 μm and the pit width is about 0.5 μm, and then the size of a read light spot 201 is about 1.5 μm in diameter. If the track pitch is halved (0.8 μm), then the pit width is also reduced and the size of the read light spot 201 must be about 1 μm in diameter. Then, the numerical aperture of the objective lens 116 must also be changed, and a specialized objective lens is then needed.

[0013] In the conventional objective lens driving device shown in Fig.67, however, though the lens holder 115 is turnable and up-and-down movable, its movable range is limited to a range for focusing adjustment and tracking adjustment, where a plurality of lenses can not be appropriately switched and used.

<Second Conventional Example of Optical Information Recording/Regenerating Device>

[0014] Optical information recording/regenerating devices having a plurality of objective lenses also exist. As an example, Fig.70 shows an optical information recording/regenerating device provided with a plurality of objective lens driving devices.

[0015] In Fig.70, 211a and 221b denote objective lens driving devices having objective lenses 209 and 210. The reference characters 212a and 212b denote controlling coils for controlling radial feed provided on the objective lens driving devices 211a and 211b, 213 denotes a base, 214a and 214b denote radial direction controlling magnetic circuits fixedly provided on the base 213, 215a and 215b denote shafts fixedly provided on the base 213 for forming moving axes of the objective lens driving devices 211a and 211b, and 216 denotes a disk-like optical information recording medium. Application of a desired current to the radial direction controlling coils drives the objective lens driving devices 211a and 211b in the direction shown by the arrow B to make radial feed, and then the objective lenses 209 and 210 can be moved in the diameter direction of the optical information recording medium 216, i.e., in the direction shown by the arrow B.

[0016] Here, if the objective lenses 209 and 210 are objective lenses corresponding to optical information recording media with substrate thicknesses 0.6 mm and 1.2 mm, recording and regeneration suitable for the respective media can be performed. If two kinds of objective lenses having different light condensing characteristics (e.g., numerical aperture) are provided to adapt to media with different recording densities, recording and regeneration suitable for the respective recording densities can be performed.

<Third Conventional Example of Optical Information Recording/Regenerating Device>

[0017] Fig.71 shows an important part of an optical information recording/regenerating device shown in Japanese Patent Laying-Open No.6-333255 as another example. In the figure, 601 denotes an optical information recording medium having a substrate thickness t1 and 601a denotes a signal surface. 602 denotes an objective lens for the substrate thickness t1 and 603 denotes an objective lens for a substrate thickness t2 (here, t2 is assumed to be larger than t1), where both lenses are held by the lens holder 604 to be integrally driven by an objective lens driving mechanism not shown. 605 denotes a beam separating mirror including a mirror surface 605a and a half mirror surface 605b.

[0018] Next, the operation thereof will be described. The laser beam 606 emitted from a light source not shown impinges upon the beam separating mirror 605 from the right and is first separated into transmitted light and reflected light at the half mirror surface 605b, and the reflected light enters the objective lens 603. The transmitted light is totally reflected at the mirror surface 605a to enter the objective lens 602. Now, as the thickness of the optical information recording medium 601 is tl, the objective lens driving mechanism not shown controls so that the laser beam 607 coming from the objective lens 602 focuses on the signal surface 601a of the optical information recording medium 601. At this time, the laser beam 608 is also coming from the objective lens 603, but since it is a lens for an optical information recording medium with a thickness larger than tl, it focuses on the farther side of the signal surface 601a not to affect recording or regenerating. This way, in the case of an optical information recording medium with the thickness tl, the objective lens 602 is selected to record or regenerate information. In the case of an optical information recording medium with the thickness t2, the objective lens 603 is selected to record or regenerate information, then the laser beam 607 emitted from the objective lens 602 focuses on this side of the signal sur-

face 601a not to affect the recording or regenerating at all.

[0019] In the half mirror surface 605b, its transmission factor and reflection factor can be set to the most suitable values in advance in accordance with optical characteristics of optical information recording media recorded or regenerated with the objective lens 602 and the objective lens 603.

<Fourth Conventional Example of Optical Information Recording/Regenerating Device>

[0020] Another example is an optical information recording/regenerating device disclosed in Japanese Patent Laying-Open No.7-98431. Fig.72 is a schematic sectional view of a compound objective lens provided in the conventional optical information recording/regenerating device and Fig.73 is a schematic sectional view of an optical system of the conventional optical information recording/regenerating device.

[0021] In Fig.72, 704 denotes an objective lens and 707 denotes a hologram lens. The hologram lens 707 is formed on a substrate 709 transparent to the light beam 703 and it has a coaxial grating pattern 707a, of which center coincides with the objective lens 704. It is designed so that the diffraction efficiency of the first-order diffraction light of the hologram lens 707 is less than 100 percent and the transmitted light (zero-order diffraction light) 761a of the light beam 703a also has sufficient intensity.

[0022] In Fig.73, 702 is a radiation light source, such as a semiconductor laser. The light beam 703 emitted from the radiation light source 702 is made almost parallel by the collimator lens 722, transmitted through the beam splitter 736 to enter the hologram lens 707 and the objective lens 704, and is condensed upon the optical information recording medium. The light beam reflected at the optical information recording medium reversely passes along the original light path, and the transmitted light 761 is transmitted through the hologram lens again, reflected at the beam splitter 736, condensed by the convergent lens 721, and enters the photodetector 707.

[0023] Next, the operation will be described. The objective lens 704 is designed so that, when the light beam 761 transmitted through the hologram lens 707 without being diffracted enters there, it can form a condensed light spot at the diffraction limit on the optical information recording medium with a thin substrate. The first-order diffraction light 764 diffracted at the hologram lens 707 is condensed onto the optical information recording medium with a thick substrate by the objective lens 704. Here, the first-order diffraction light 764 is aberration-corrected so that it can be condensed to the diffraction limit onto the optical information recording medium with a thick substrate.

[0024] This way, as this optical head device always has two focuses, it can form a suitable light spot either on an optical information recording medium with a thick substrate or an optical information recording medium with a thin substrate to record or regenerate information.

[0025] Output of the photodetector 707 is operated to produce a focusing error signal and a tracking error signal, according to which the objective lens 704 is drive-controlled to correct the focusing error and tracking error of the light spot.

[0026] The optical information recording/regenerating device of the first conventional example constructed as described above has a problem that a plurality of objective lens driving devices are needed or the device is large-sized or complicated with a large number of parts to adapt to differences of recording density and substrate thickness of the optical information recording media with which information is recorded or regenerated, thus providing a considerable increase in cost.

[0027] The optical information recording/regenerating device of the second and third conventional example constructed as described above has a disadvantage of inferior efficiency of use of laser beam, where an expensive high-output semiconductor laser must be used as a light source to cover the disadvantage.

[0028] As for the point of previously setting the transmission factor and the reflection factor of the half mirror surface to predetermine values in accordance with the optical characteristics of the optical information recording medium, variations can not be avoided in manufacturing, which needs strict manufacturing control and selection.

[0029] Furthermore, the transmission factor and the reflection factor of a half mirror surface are generally frequency dependent and the semiconductor laser serving as a light source causes fluctuation of frequency depending on environment temperature and optical output, so that the transmission factor and reflection factor can not necessarily be kept at predetermined values. Fluctuation of transmission factor and reflection factor causes fluctuation of the light amount of the laser beam applied onto the optical information recording medium, which will cause deterioration of quality of recording signal and regenerating signal.

[0030] The optical information recording/regenerating device of the third and fourth conventional example constructed as described above in which the light beam emitted from a light source is always separated into a plurality of light beams by a hologram lens has a problem that the efficiency of use of the light beam is bad and an expensive high power semiconductor laser must be used as a light source.

[0031] Furthermore, as a plurality of light beams always exist in the same optical path, they may interfere with each other or one beam may become stray light to deteriorate quality of regenerating signal, or to cause offset in focusing or tracking error signal.

[0032] Moreover, a hologram lens is very expensive and has bad productivity, resulting in a high price of the optical head.

SUMMARY OF THE INVENTION

[0033] A first aspect of the present invention is directed to an objective lens driving device, comprising: a lens holder held turnable around an axis line and up-and-down movable along the axis line; a plurality of objective lenses provided on the lens holder in positions eccentrically displaced by almost equal distances from the axis line; driving means for driving a light spot on an optical information recording medium in a focus direction and a direction across a track by operation of moving up and down the lens holder along the axis line and operation of turning the lens holder around the axis line; and means for outputting a distinguishment signal corresponding to a kind of the optical information recording medium; wherein one of the plurality of objective lenses is selected according to the distinguishment signal and moved into a luminous flux to form a predetermine light spot corresponding to the kind of the optical information recording medium,

[0034] According to the objective lens driving device of the first aspect of the present invention, with a lens holder held rotatable around the axis line and up and down movable along the axis line and a plurality of objective lenses provided on the lens holder in positions eccentrically displaced by almost equal distances from the axis line, an objective lens is selected corresponding to differences in substrate thickness and recording density of an optical information recording medium and moved into a luminous flux to form a light spot to record/regenerate information, which provides an optical information recording/regenerating device with a simple structure and a small number of parts and of low price and small size, and capable of recording or regenerating optical information recording media with different substrate thicknesses and recording densities under the most suitable optical conditions. Especially, as the method of defining the operation direction of the lens holder and the method of defining the operation center can be separated, switch of the objective lenses can be made smoothly. Furthermore, as it is dynamically well-balanced in the turning direction, operations in the up and down and turning directions can be stable without any change when any of the objective lenses are selected.

[0035] Preferably, according to a second aspect of the present invention, the lens holder has steps which differ for each of the plurality of objective lenses in portions where the plurality of objective lenses are to be mounted.

[0036] According to the objective lens driving device according to the second aspect of the present invention, even if a plurality of objective lenses with different specifications held by the lens holder are selected and used, the positional relation between the optical information recording medium and the lens holder is constant, so that the movable amount in the focusing direction can be constant, thus providing stable operation and small-sizing and simplifying the objective lens driving device.

[0037] Preferably, according to a third aspect of the present invention, the operation of turning the lens holder around the axis line and the operation of selecting and moving into the luminous flux one of the plurality of objective lenses are made by using the driving means in common.

[0038] According to the objective lens driving device of the third aspect of the present invention, the means for selecting the objective lenses and moving the objective lens into a luminous flux and the means for turning the lens holder about the supporting axis can be implemented using the same driving device, thus providing an objective lens driving device which is low-priced and small-sized with a small number of parts.

[0039] Preferably, according to a fourth aspect of the present invention, the objective lens driving device further comprises center point restoring force generating means of the same number as or a larger number than the objective lenses to generate a center point restoring force for each of the plurality of objective lenses.

[0040] According to the objective lens driving device of the fourth aspect of the present invention, as it is configured to generate a center point restoring force for each of the plurality of objective lenses, the operation center position of each objective lens can easily be defined and stable and reliable control operation can be achieved for each objective lens. Furthermore, as the repulsion force generated when selecting and moving the objective lens can be small, a small-sized and low-priced objective lens driving device can be obtained.

[0041] Preferably, according to a fifth aspect of the present invention, the objective lens driving device further comprises means for limiting a turning range of the lens holder to limit a range of movement of the plurality of objective lenses.

[0042] According to the objective lens driving device of the fifth aspect of the present invention, as the range of moving the objective lens is limited, the objective lens will not overmove when selected and moved, thus providing quick positioning.

[0043] Preferably, according to a sixth aspect of the present invention, the objective lens driving device further comprises means for detecting which of the plurality of objective lenses is being selected.

[0044] According to the objective lens driving device of the sixth aspect of the present invention, it is distinguished which of the plurality of objective lenses is being selected, thus providing quick and correct selection of the objective lens.

[0045] Preferably, according to a seventh aspect of the present invention, the objective lens driving device further comprises means for detecting a turned position of the lens holder.

[0046] According to the objective lens driving device of the seventh aspect of the present invention, as the rotating position of the lens holder is detected, it can be distinguished which of the plurality of objective lenses

is being selected, so that the objective lens can be selected quickly. Furthermore, a restoring force can be electrically generated to the lens holder, reducing the number of parts, and providing stable control operation without mechanical restriction of the operation range.

[0047] Preferably, according to an eighth aspect of the present invention, the driving means comprises transverse direction driving means for driving the lens holder in a direction across the track, and the transverse direction driving means is of the same number as or a larger number than the number of the plurality of objective lenses.

[0048] According to the objective lens driving device of the eighth aspect of the present invention provided with the transverse direction driving means for driving the lens holder in the direction across the track of the same number as or a larger number than the number of objective lenses, the driving force can be obtained efficiently to reduce the power consumption of the device. Furthermore, it can easily be adapted to an increase of the rotation number of the optical information recording media.

[0049] Preferably, according to a ninth aspect of the present invention, the operation of turning the lens holder around the axis line and the operation of selecting and moving into the luminous flux one of the plurality of objective lenses are made by using the driving means partially in common.

[0050] According to the objective lens driving device of the ninth aspect of the present invention, the means for selecting the objective lens and moving the objective lens into a luminous flux and the means for turning the lens holder about the supporting axis are partially shared, so that the objective lens can be moved efficiently.

[0051] Preferably according to a tenth aspect of the present invention, the plurality of objective lenses are arranged in positions almost symmetrical about the supporting axis line on the lens holder.

[0052] According to the objective lens driving device of the tenth aspect of the present invention, as the plurality of objective lenses are arranged almost symmetrical about the supporting axis line on the lens holder, members for driving are symmetrically arranged, which removes the necessity of providing extra driving members, reducing the number of parts to provide a low-priced and small-sized objective lens driving device.

[0053] An eleventh aspect of the present invention is directed to an objective lens driving device, comprising: a lens holder held turnable around an axis line and up-and-down movable along the axis line; a plurality of objective lenses provided on the lens holder in positions eccentrically displaced by almost equal distances from the axis line; driving means for driving a light spot on an optical information recording medium in a focus direction and a direction across a track by operation of moving up and down the lens holder along the axis line and operation of turning the lens holder around the axis line; means for outputting a distinguishment signal corresponding to a kind of the optical information recording medium; and luminous flux path changing means for changing a path of a luminous flux according to the distinguishment signal to cause the luminous flux to selectively enter one of the plurality of objective lenses; wherein a predetermined light spot is formed corresponding to the kind of the optical information recording medium.

[0054] According to the objective lens driving device of the eleventh aspect of the present invention including means for distinguishing substrate thicknesses of optical information recording media to select an objective lens which the luminous flux enter according to differences in substrate thickness and recording density, the rotation amount of the lens holder can be reduced and the lens holder can easily be well-balanced about the supporting axis, which removes the necessity of a member such as a balancer, providing a low-priced and small-sized objective lens driving device.

[0055] A twelfth aspect of the present invention is directed to -an objective lens driving device, comprising: an elastic member having flexibility in an up and down direction of an axis line almost perpendicular to an optical information recording medium surface; a lens holder provided to be supported by the elastic member and turnable around the axis line as a supporting point; a plurality of objective lenses provided on the lens holder in positions eccentrically displaced by almost equal distances from the axis line; driving means for driving a light spot on an optical information recording medium in a focus direction and a direction across a track by operation of moving up and down the lens holder along the axis line and operation of turning the lens holder around the axis line; and means for outputting a distinguishment signal corresponding to a kind of the optical information recording medium; wherein one of the plurality of objective lenses is selected according to the distinguishment signal and moved into a luminous flux to form a predetermine light spot corresponding to the kind of the optical information recording medium.

[0056] According to the objective lens driving device of the twelfth aspect of the present invention which includes an elastic member movable in the up and down direction of the axis line almost perpendicular to the optical information recording medium surface, a lens holder held by the elastic member and supported rotatable around the axis line as a supporting point and a plurality of objective lenses provided in positions displaced by almost equal distances from the axis line on the lens holder, the objective lenses are selected corresponding to differences in substrate thickness and recording density of optical information recording media and moved into a luminous flux to form a light spot to record and regenerate information, thus providing an objective lens driving device with which an optical information recording/regenerating device can be realized which is low-priced and small-sized with simple structure and a small

number of parts and which can apply recording/regenerating to optical information recording media with different substrate thicknesses.

[0057] A thirteenth aspect of the present invention is directed to an optical information recording/regenerating device, comprising: a light source; a plurality of objective lenses provided on a single lens holder; means for moving and setting the plurality of objective lenses provided on the lens holder to a position where a light beam emitted from the light source is incident; means for selecting an objective lens suitable for an optical information recording medium; and driving means for correcting a focusing error and a tracking error of a light spot condensed by the selected objective lens on the optical information recording medium by driving the lens holder.

[0058] According to the optical information recording/regenerating device of the thirteenth aspect of the present invention, as objective lenses corresponding to different kinds of optical information recording media are exclusively provided, a light spot can be formed with an objective lens the most suitable for each optical recording medium. Accordingly, good recording or regenerating characteristics can be realized with a single optical information recording/regenerating device, thus providing an optical information recording/regenerating device of low price and small size.

[0059] A fourteenth aspect of the present invention is directed to an objective lens driving device. comprising: a lens holder held turnable around an axis line and up-and-down movable along the axis line; a plurality of objective lenses provided on the lens holder in positions eccentrically displaced by almost equal distances from the axis line; driving means for driving a light spot on an optical information recording medium in a focus direction and a direction across a track by operation of moving up and down the lens holder along the axis line and operation of turning the lens holder around the axis line; a fixing base holding the lens holder; and means for outputting a distinguishment signal corresponding to a kind of the optical information recording medium; the driving means having a plurality of coils provided on the lens holder and a plurality of magnets fixed to predetermined positions on the fixing base, the plurality of coils having power supplying means for electric power supply, wherein one of the plurality of objective lenses is selected according to the distinguishment signal and moved into a luminous flux to form a predetermined light spot corresponding to the kind of the optical information recording medium.

[0060] According to the objective lens driving device of the fourteenth aspect of the present invention which includes a lens holder held turnable about an axis line and up and down movable along the axil line and a plurality of objective lenses provided on the lens holder in positions eccentrically displaced by almost equal distances from the axis line, the objective lens being selected corresponding to differences in substrate thickness and recording density of optical information recording media and moved into a luminous flux to form a light spot to record/regenerate information, an optical information recording/regenerating device can be realized with simple structure and a small number of parts, low-priced and small-sized, and capable of recording or regenerating of optical information recording media with different substrate thicknesses and recording densities under the most suitable optical conditions.

[0061] Preferably, according to a fifteenth aspect of the present invention, the power supplying means is provided being divided almost symmetrically about a line connecting the axis line and the center between the plurality of objective lenses.

[0062] According to the objective lens driving device of the fifteenth aspect of the present invention, the repulsion force generated by the power supplying means does not depend on the driving direction of the objective lens and is constant if any of the objective lenses is selected, which provides stable driving control of the objective lenses.

[0063] Preferably, according to a sixteenth aspect of the present invention, the power supplying means is comprised of a flexible printed wiring board.

[0064] According to the objective lens driving device of the sixteenth aspect of the present invention, the electrically connecting work between the lens holder and the fixed portion is simplified to improve the workability, and the shape of the power supplying means is stably formed and driving control of the objective lenses can be made stably. Furthermore, a damping effect of the movable portion can be obtained, enabling stable track jump operation.

[0065] Preferably, according to a seventeenth aspect of the present invention, the power supplying means is arranged so that one end of each of its forward path and its backward path is positioned in the vicinity of the center of gravity of the lens holder.

[0066] According to the objective lens driving device of the seventeenth aspect of the present invention, the repulsion force generated by the power supplying means is applied in the vicinity of the center of gravity of the lens holder, not affecting drive of the objective lenses, so that control can be made stably.

[0067] Preferably, according to an eighteenth aspect of the present invention, the lens holder has a coil positioning portion, and the power supplying means has its one end fixed to the coil positioning portion.

[0068] According to the objective lens driving device of the eighteenth aspect of the present invention, positioning of the power supplying means on the lens holder side can easily be achieved and the workability is improved. Furthermore, the shape of the power supplying means is stably formed and the driving control of the objective lenses can be made stably.

[0069] Preferably, according to a nineteenth aspect of the present invention, the lens holder has means for restricting movement of the power supplying means at a

position facing the coil positioning portion.

[0070] According to the objective lens driving device of the nineteenth aspect of the present invention, the shape of the power supplying means is formed stably and the driving control of the objective lenses can be achieved stably.

[0071] Preferably, according to a twentieth aspect of the present invention, the means for restricting movement of the power supplying means is an almost cylindrical boss formed to project from the lens holder surface.

[0072] According to the objective lens driving device of the twentieth aspect of the present invention, the lens holder and the restricting means can be formed as one and therefore the number of parts can be reduced and the working processes can also be reduced.

[0073] Preferably, according to a twenty-first aspect of the present invention, the fixing base has a coil positioning portion, and the power supplying means has its one end fixed to the coil positioning portion.

[0074] According to the objective lens driving device of the twenty-first aspect of the present invention, positioning of the power supplying means on the fixed side can easily be made and the workability is improved. Furthermore. the shape of the power supplying means can be formed stably and driving control of the objective lenses can be made stably.

[0075] Preferably, according to a twenty-second aspect of the present invention, the flexible printed wiring board has its main surface arranged vertical to the optical information recording medium.

[0076] According to the objective lens driving device of the twenty-second aspect of the present invention, as the repulsion force by the power supplying means working in the turning direction is stable, driving control of the objective lenses can be made stably.

[0077] Preferably, according to a twenty-third aspect of the present invention, the plurality of objective lenses are arranged at an angle almost symmetrical about the supporting axis on the lens holder, and the number of the plurality of coils is equal to or larger than the number of the plurality of objective lenses, at least two of the coils being arranged at an angle almost the same as the arrange angle of the plurality of objective lenses.

[0078] According to the objective lens driving device of the twenty-third aspect of the present invention, the number of magnets can be minimized, reducing the number of parts, which provides an objective lens driving device of low price, with reduced working steps.

[0079] Preferably, according to a twenty-fourth aspect of the present invention, the plurality of objective lenses respectively have different aperture diameters, and one of the plurality of objective lenses having the smallest aperture diameter is disposed in a position close to the rotation center of the optical information recording medium.

[0080] According to the objective lens driving device of the twenty-fourth aspect of the present invention, the objective lenses will not collide with the turntable and an objective lens driving device with high reliability is obtained, and the freedom of design of the mechanical portion is increased.

[0081] Preferably, according to a twenty-fifth aspect of the present invention, the plurality of objective lenses respectively have different working distances, and one of the plurality of objective lenses having the largest working distance is disposed in a position close to the rotation center of the optical information recording medium.

[0082] According to the objective lens driving device of the twenty-fifth aspect of the present invention, the objective lenses will not collide with the turntable and an objective lens driving device with high reliability is obtained, and the freedom of design of the mechanical portion is increased.

[0083] Preferably, according'to a twenty-sixth aspect of the present invention, the plurality of objective lenses are arranged at an angle almost symmetrical about the supporting axis line on the lens holder, and the driving means has a plurality of magnetic materials in positions corresponding to the plurality of coils of the lens holder, at least two of the plurality of magnetic materials being arranged at an angle almost the same as the arrange angle of the plurality of objective lenses.

[0084] According to the objective lens driving device of the twenty-sixth aspect of the present invention, the neutral position of the plurality of objective lenses can be maintained with a minimum number of magnets, so that the number of parts can be reduced and an objective lens driving device of low price can be obtained, and the working steps can also be reduced.

[0085] Preferably, according to a twenty-seventh aspect of the present invention, the lens holder has a plurality of cut portions in positions corresponding to the plurality of coils of the lens holder, and the magnetic materials are inserted and fixed in the plurality of cut portions.

[0086] According to the objective lens driving device of the twenty-seventh aspect of the present invention, the magnetic materials can easily be positioned to improve the workability and stable magnetic damper effect is obtained so that driving control of the objective lenses can be made stably.

[0087] Preferably, according to a twenty-eighth aspect of the present invention, the plurality of magnetic materials are integrally formed to the lens holder.

[0088] According to the objective lens driving device of the twenty-eighth aspect of the present invention, the lens holder and the means for holding the neutral positions of the plurality of objective lenses can be formed as one, reducing the number of parts and the working steps.

[0089] Preferably, according to a twenty-ninth aspect of the present invention, the lens holder has a projection projecting in a direction toward the fixing base to limit a turning range of the lens holder with contact between

an upper surface of the fixing base and the projection.

[0090] According to the objective lens driving device of the twenty-ninth aspect of the present invention, as the range of turning the lens holder can easily be limited without increasing the number of parts, the driving control of the objective lenses can be made stably, resulting in a low-priced objective lens driving device, with a less number of working steps.

[0091] According to a thirtieth aspect of the present invention, the fixing base has a first fixing base serving as a base and a second fixing base holding the lens holder, the first fixing base having a spherical portion which is partially spherical on a lower surface side and a lowered step portion on an upper surface side corresponding to the spherical portion, the second fixing base being fixed to the step portion of the first fixing base.

[0092] According to the objective lens driving device of the thirtieth aspect of the present invention, the objective lens driving device can be made thinner, resulting in down-sizing of the optical head device, and the optical information recording/regenerating device.

[0093] Preferably, according to a thirty-first aspect of the present invention, the fixing base has on its lower surface side a spherical portion which is partially spherical, the spherical portion having its center in the vicinity of an intersection of a plane parallel to an optical information recording medium including a principal point of the objective lens and the axis line.

[0094] According to the objective lens driving device of the thirty-first aspect of the present invention, the moved amount of the objective lens in the plane direction is small when inclination angle of the objective lens driving device is adjusted and the objective lens can be held almost at the center in the light beam, so that an optical head device with good quality of regeneration signal is obtained. Furthermore, the movable amount of the objective lens driving device in the tracking direction can be larger.

[0095] Preferably, according to a thirty-second aspect of the present invention, the plurality of coils are electrically connected in series.

[0096] According to the objective lens driving device of the thirty-second aspect of the present invention, it is satisfactory to use a single conventional driving circuit for driving the objective lens driving device, resulting in an optical information according/regenerating device of low price.

[0097] Preferably, according to a thirty-third aspect of the present invention, the plurality of coils are formed by continuous winding.

[0098] According to the objective lens driving device of the thirty-third aspect of the present invention, the coils can be formed as one, which reduces the number of parts and provides an objective lens driving device of low price, with a reduced number of working steps.

[0099] Preferably, according to a thirty-fourth aspect of the present invention, the magnetic material is cylindrical.

[0100] According to the objective lens driving device of the thirty-fourth aspect of the present invention, the shape of the magnetic material can be made easily, and an objective lens driving device of low price can be obtained.

[0101] Preferably, according to a thirty-fifth aspect of the present invention, the means for restricting movement of the power supplying means is a cubic wall formed to project from the lens holder surface.

[0102] According to the objective lens driving device of the thirty-fifth aspect of the present invention, as the shape of the power supplying means can be formed easily and stably, driving control of the objective lenses can be made stably.

[0103] Preferably, according to a thirty-sixth aspect of the present invention, the fixing base has a hole into which a supporting shaft serving as the axis line can be inserted, a cylindrical portion formed almost coaxial with the hole, a plurality of side walls and a spherical portion.

[0104] According to the objective lens driving device of the thirty-sixth aspect of the present invention, the fixing base can be formed as one, so that the number of parts is reduced and an objective lens driving device of low price can be obtained, and the working steps can also be reduced.

[0105] Preferably, according to a thirty-seventh aspect of the present invention, the fixing base is a sintered material containing iron.

[0106] According to the objective lens driving device of the thirty-seventh aspect of the present invention, the fixing base can be formed into a complicated form, resulting in an objective lens driving device with good driving efficiency.

[0107] Preferably, according to a thirty-eighth aspect of the present invention, the fixing base is a sheet material containing iron.

[0108] According to the objective lens driving device of the thirty-eighth aspect of the present invention, the fixing base can be made easily, and a low-priced objective lens driving device can be obtained.

[0109] Preferably, according to a thirty-ninth aspect of the present invention, the lens holder has an engaging portion for positioning arrangement of the plurality of objective lenses and fixing the plurality of objective lenses by engagement.

[0110] According to the objective lens driving device of the thirty-ninth aspect of the present invention, the lens holder can be made easily and a low-priced objective lens driving device can be obtained, and as the plurality of objective lenses can be disposed at a close distance, the operation of switching the objective lenses can be made stably.

[0111] Preferably, according to a fortieth aspect of the present invention, the plurality of coils have a plurality of sets of coils electrically connected in series, the sets of coils electrically connected in series being connected in parallel.

[0112] According to the objective lens driving device

of the fortieth aspect of the present invention, as the driving efficiency of the objective lens driving device is improved, performance of the optical information recording/regenerating device can be improved and the power consumption can be reduced.

[0113] Preferably, according to a forty-first aspect of the present invention, the number of plurality of magnets is equal to or larger than the number of plurality of coils.

[0114] According to the objective lens driving device of the forty-first aspect of the present invention, the good driving efficiency and the simple driving circuit improve the performance of the optical information recording/regenerating device and reduce the power consumption. Furthermore, an objective lens driving device of low price and with good workability can be obtained.

[0115] Preferably, according to a forty-second aspect of the present invention, the plurality of objective lenses are arranged at an angle almost symmetrical about the supporting axis line on the lens holder, the number of the plurality of magnets is equal to or larger than the number of the plurality of objective lenses, and at least two of the magnets are arranged at an angle almost symmetrical about the supporting axis on the lens holder.

[0116] According to the objective lens driving device of the forty-second aspect of the present invention, the number of coils can be minimized, so that a low-priced objective lens driving device with a reduced number of parts can be obtained, and also with a reduced number of working steps.

[0117] A forty-third aspect of the present invention is directed to an optical information recording/regenerating device, comprising: an objective lens driving device including, a lens holder held turnable around an axis line and up-and-down movable along the axis line, a plurality of objective lenses provided on the lens holder in positions eccentrically displaced by almost equal distances from the axis line, driving means for driving a light spot on an optical information recording medium in a focus direction and a direction across a track by operation of moving up and down the lens holder along the axis line and operation of turning the lens holder around the axis line, and means for outputting a distinguishment signal corresponding to a kind of the optical information recording medium, wherein one of the plurality of objective lenses is selected according to the distinguishment signal and moved into a luminous flux to form a predetermine light spot corresponding to the kind of the optical information recording medium; a light source serving as a source of the light spot; a first optical element for dividing a light beam emitted from the light source into a plurality of light beams at a predetermine dratio; a second optical element for almost transmitting the divided light beams and reflecting the reflected light beam reflected from the optical information recording medium at a predetermines angle to change the light path; a third optical element for making the light beam transmitted through the second optical element almost parallel; a fourth optical element for almost totally reflecting the light beam made parallel and the reflected light beam reflected from the optical information recording medium at a predetermined angle to cause the light beam to enter a selected one of the plurality of objective lenses; and a light receiving element for receiving the reflected light beam having its optical path changed by the second optical element.

[0118] A forty-fourth aspect of the present invention is directed to an optical information recording/regenerating device, comprising: an objective lens driving device, comprising, a lens holder held turnable around an axis line and up-and-down movable along the axis line, a plurality of objective lenses provided on the lens holder in positions eccentrically displaced by almost equal distances from the axis line, driving means for driving a light spot on an optical information recording medium in a focus direction and a direction across a track by operation of moving up and down the lens holder along the axis line and operation of turning the lens holder around the axis line, means for outputting a distinguishment signal corresponding to a kind of the optical information recording medium, and luminous flux path changing means for changing a path of a luminous flux according to the distinguishment signal to cause the luminous flux to selectively enter one of the plurality of objective lenses, wherein a predetermined light spot is formed corresponding to the kind of the optical information recording medium; a light source serving as a source of the light spot; a first optical element for dividing a light beam emitted from the light source into a plurality of light beams at a predetermined ratio;a second optical element for almost transmitting the divided light beams and reflecting the reflected light beam reflected from the optical information recording medium at a predetermined angle to change the light path; a third optical element for making the light beam transmitted through the second optical element almost parallel; a fourth optical element for almost totally reflecting the light beam made parallel and the reflected light beam reflected from the optical information recording medium at a predetermined angle to cause the light beam to enter a selected one of the plurality of objective lenses; and a light receiving element for receiving the reflected light beam having its optical path changed by the second optical element.

[0119] A forty-fifth aspect of the present invention is directed to an optical information recording/regenerating device, comprising: an objective lens driving device including, an elastic member having flexibility in an up and down direction of an axis line almost perpendicular to an optical information recording medium surface, a lens holder provided to be supported by the elastic member and turnable around the axis line as a supporting point, a plurality of objective lenses provided on the lens holder in positions eccentrically displaced by almost equal distances from the axis line, driving means for driving a light spot on an optical information recording medium in a focus direction and a direction across a

track by operation of moving up and down the lens holder along the axis line and operation of turning the lens holder around the axis line, and means for outputting a distinguishment signal corresponding to a kind of the optical information recording medium, wherein one of the plurality of objective lenses is selected according to the distinguishment signal and moved into a luminous flux to form a predetermined light spot corresponding to the kind of the optical information recording medium; a light source serving as a source of the light spot; a first optical element for dividing a light beam emitted from the light source into a plurality of light beams at a predetermined ratio; a second optical element for almost transmitting the divided light beams and reflecting the reflected light beam reflected from the optical information recording medium at a predetermined angle to change the light path; a third optical element for making the light beam transmitted through the second optical element almost parallel; a fourth optical element for almost totally reflecting the light beam made parallel and the reflected light beam reflected from the optical information recording medium at a predetermined angle to cause the light beam to enter a selected one of the plurality of objective lenses; and a light receiving element for receiving the reflected light beam having its optical path changed by the second optical element.

[0120] A forty-sixth aspect of the present invention is directed to an optical information recording/regenerating device, comprising: an objective lens driving device including, a lens holder held turnable around an axis line and up-and-down movable along the axis line, a plurality of objective lenses provided on the lens holder in positions eccentrically displaced by almost equal distances from the axis line, driving means driving a light spot on an optical information recording medium in a focus direction and a direction across a track by operation of moving up and down the lens holder along the axis line and operation of turning the lens holder around the axis line, a fixing base holding the lens holder, and means for outputting a distinguishment signal corresponding to a kind of the optical information recording medium, the driving means having a plurality of coils provided on the lens holder and a plurality of magnets fixed in predetermined positions on the fixing base, the plurality of coils having power supplying means for electric power supply, wherein one of the plurality of objective lenses is selected according to the distinguishment signal and moved into a luminous flux to form a predetermined light spot corresponding to the kind of the optical information recording medium; a light source serving as a source of the light spot; a first optical element for dividing a light beam emitted from the light source into a plurality of light beams at a predetermined ratio;a second optical element for almost transmitting the divided light beams and reflecting the reflected light beam reflected from the optical information recording medium at a predetermined angle to change the light path; a third optical element for making the light beam transmitted through the second optical element almost parallel; a fourth optical element for almost totally reflecting the light beam made parallel and the reflected light beam reflected from the optical information recording medium at a predetermined angle to cause the light beam to enter a selected one of the plurality of objective lenses; and a light receiving element for receiving the reflected light beam having its optical path changed by the second optical element.

[0121] According to the optical information recording/regenerating device of the forty-third to forty-sixth aspects of the present invention, different kinds of objective lenses respectively corresponding to different kinds of optical information recording media are selected and moved onto a light beam to form a light spot, which provides a low-priced and small-sized optical information recording/regenerating device.

[0122] Preferably, according to forty-seventh through fiftieth aspects of the present invention, the optical information recording/regenerating device further comprises a current voltage converting circuit, a focusing error generating circuit, a tracking error generating circuit, a regeneration signal detecting circuit, a circuit generating a pulse current when an objective lens corresponding to the distinguishment signal in the plurality of objective lenses is not disposed in an optical path, and a driving device driving circuit for driving the objective lens driving device.

[0123] According to the optical information recording/regenerating device of the forty-seventh through fiftieth aspects of the present invention, a low-priced and small-sized optical information recording/regenerating device can be obtained which can record and regenerate information with different kinds of optical information recording media.

[0124] A fifty-first aspect of the present invention is directed to an optical information recording/regenerating device in which a laser beam emitted from a laser light source is led to an objective lens by a single optical path system and condensed and applied onto an optical information recording medium by the objective lens to optically record or regenerate information, comprising: a plurality of objective lenses having the most suitable optical characteristics corresponding to different kinds of the optical information recording media; means for selecting one of the plurality of objective lenses corresponding to a kind of the optical information recording medium subject to recording or regenerating; and means for switching light intensity of the laser beam emitted from the laser light source corresponding to the selected objective lens.

[0125] According to the optical information recording/regenerating device of the fifty-first aspect of the present invention, with two objective lenses provided, the light intensity of the laser beam emitted from the light source is switched while switching the two objective lenses according to different kinds of optical information recording media, producing the effects of using the laser beam ef-

fectively and performing stable regeneration with detected electric signal having predetermined magnitude.

[0126] Preferably, according to the optical information recording/regenerating device of a fifty-second aspect of the present invention, the means for switching the light intensity of the laser beam includes high frequency current value switching means for switching a value of a high frequency current applied to the laser light source together with a driving current for recording or regenerating to a different value corresponding to the selected objective lens.

[0127] According to the optical information recording/regenerating device of the fifty-second aspect of the present invention, as the high frequency superposed current injected into the semiconductor laser is switched as the optical output is switched, noise of the semiconductor laser can be suppressed independent of the optical output, producing the effect of stable regeneration.

[0128] A fifty-third aspect of the present invention is directed to an optical information recording/regenerating device in which a laser beam emitted from a laser light source is led to an objective lens by a single optical path system and condensed and applied onto an optical information recording medium by the objective lens to optically record or regenerate information, comprising: a plurality of objective lenses having the most suitable optical characteristics corresponding to different kinds of optical information recording media; means for selecting one of the plurality of objective lenses corresponding to a kind of the optical information recording medium subject to recording or regenerating; a photodetector receiving a laser beam reflected from the optical information recording medium; signal detecting means for detecting an information signal and an error signal from an output signal of the photodetector; and means for switching an amplification degree of the signal detecting means corresponding to the selected objective lens.

[0129] Preferably, according to a fifty-fifth aspect of the present invention, the means for switching an amplification degree of the signal detecting means includes voltage converting means for converting an output current of the photodetector into a voltage, and means for switching a value of load resistance of the voltage converting means.

[0130] According to the optical information recording/regenerating device of the fifty-third and fifty-fifth aspects of the present invention, the reflected light from the optical information recording medium is detected to switch the amplification degree of the electric circuit generating the electric signal while the objective lens is switched according to the kind of the optical information recording medium, which produces the effect of enabling stable regeneration with predetermined magnitude of signal independent of the kind of the optical information recording medium.

[0131] Preferably, according to a fifty-fourth aspect of the present invention, the optical information recording/regenerating device further comprises means for switching light intensity of the laser beam emitted from the laser light source corresponding to the selected objective lens. According to the optical information recording/regenerating device of the fifty-fourth aspect of the present invention, as the switch of the light intensity and the switch in the electric circuit are made at the same time, the laser beam can be utilized effectively and signals with predetermined magnitude are obtained independent of the kinds of the optical information recording media, thus providing stable regeneration.

[0132] Preferably, according to a fifty-sixth aspect of the present invention, the plurality of objective lenses individually have different aperture diameters or numerical apertures.

[0133] Preferably, according to a fifty-seventh aspect of the present invention, the plurality of objective lenses individually have different aperture diameters or numerical apertures.

[0134] According to the optical information recording/regenerating device of the fifty-sixth and fifty-seventh aspects of the present invention, since the two objective lenses have different aperture diameters or numerical apertures, condensed light spots of different sizes are obtained, enabling recording or regenerating with optical information recording media with different recording densities.

[0135] Preferably, according to a fifty-eighth aspect of the present invention, the signal detecting means includes means for correcting the amplification degree of the signal detecting means on the basis of a kind of the information recording medium and magnitude of the reflected laser beam.

[0136] According to the optical information recording/regenerating device of the fifty-eighth aspect of the present invention, the switch of the light intensity and the switch in the electric circuit are corrected on the basis of the electric signal obtained from the reflected light from the optical information recording medium, which provides signals with predetermined magnitude independent of the kinds of the optical information recording media, thus providing the effect of stable regeneration.

[0137] A fifty-ninth aspect of the present invention is directed to an optical information recording/regenerating device including a dividing element for dividing a laser beam emitted from a laser light source at least into three laser beams, in which the three laser beams are led to an objective lens, and condensed and applied as three condensed light spots upon an optical information recording medium by the objective lens, the three laser beams reflected at the optical information recording medium are detected at a photodetector to optically record or regenerate information, and a tracking error signal for following up information track of the optical information recording medium is detected from at least two laser beams of the three laser beams reflected at the optical information recording medium, comprising: a plurality of objective lenses having the most suitable optical characteristics corresponding to different kinds of optical in-

formation recording media; and means for selecting one of the plurality of objective lenses in accordance with a kind of an optical information recording medium subject to recording or regenerating; wherein the dividing element inclines the laser beam by a predetermined angle so that pitch of information track of the optical information recording medium and a spot interval of the three condensed light spots formed by the selected objective lens are in proportion to each other.

[0138] According to the optical information recording/regenerating device of the fifty-ninth aspect of the present invention, the laser beam from the light source can be applied effectively to the optical information recording medium. Furthermore, as the intervals between the condensed light spots of the three beams emitted from each objective lens satisfy the most suitable conditions for the track pitch of the applied optical information recording medium, the reliability of track follow-up is improved.

[0139] Preferably, according to a sixtieth aspect of the present invention, the plurality of objective lenses individually have different focal lengths.

[0140] According to the optical information recording/regenerating device of the sixtieth aspect of the present invention, as the focal lengths of the plurality of objective lenses are not equal, the intervals between the condensed light spots of the three beams emitted from each objective lens satisfy the most suitable conditions for each track pitch of optical information recording media with different track pitches, and the reliability of the track follow-up is improved.

[0141] Preferably, according to a sixty-first aspect of the present invention, the plurality of objective lenses individually have different working distances.

[0142] According to the optical information recording/regenerating device of the sixty-first aspect of the present invention, it has the effect of enabling recording or regenerating with different kinds of optical information recording media with different substrate thicknesses.

[0143] Preferably, according to a sixty-second aspect of the present invention, the pitch of information track of the optical information recording medium and a focal length of the selected objective lens are in proportion to each other.

[0144] According to the optical information recording/regenerating device of the sixty-second aspect of the present invention, the relation of focal lengths of a plurality of objective lenses is almost proportional to the track pitches of applied optical information recording media, so that the intervals between the condensed light spots of the three beams emitted from each objective lens become suitable conditions for the track pitch of the applied optical information recording medium, producing the effect of improving the reliability of track follow-up.

[0145] Preferably, according to a sixty-third aspect of the present invention, the optical information recording/regenerating device further comprises a plurality of aperture diameter limiting means for limiting aperture diameters of lenses in correspondence with the plurality of objective lenses, at least one of the plurality of aperture diameter limiting means being provided separately from the one of the plurality of objective lenses.

[0146] According to the optical information recording/regenerating device of the sixty-third aspect of the present invention, as the means for limiting the aperture diameter of the objective lens is provided, it has the effect that the objective lens can have a predetermined numerical aperture.

[0147] Preferably, according to a sixty-fourth aspect of the present invention, the optical information recording/regenerating device further comprises a plurality of aperture diameter limiting means for limiting aperture diameters of lenses in correspondence with the plurality of objective lenses, at least one of the plurality of aperture diameter limiting means being provided integrally with. the plurality of objective lenses.

[0148] According to the optical information recording/regenerating device of the sixty-fourth aspect of the present invention, as the objective lens provided with the means for limiting the aperture is used, it has the effect of providing a low-priced objective lens.

[0149] Preferably, according to a sixty-fifth aspect of the present invention, in the plurality of objective lenses, an objective lens with a relatively short focal length has a larger numerical aperture than that of an objective lens with a relatively long focal length.

[0150] According to the optical information recording/regenerating device of the sixty-fifth aspect of the present invention, since an objective lens having a shorter focal length has a larger numerical aperture, a spot diameter dependent on the numerical aperture is obtained and recording or regenerating is well performed.

[0151] Preferably, according to a sixty-sixth aspect of the present invention, the dividing element is common to the plurality of objective lenses.

[0152] According to the optical information recording/regenerating device of the sixty-sixth aspect of the present invention, since a single laser beam dividing element is used, it has the effect that the laser beam emitted from the light source is divided in a predetermined direction.

[0153] Preferably, aecording to a sixty-seventh aspect of the present invention, an optical system for detecting the tracking error signal is common to the plurality of objective lenses.

[0154] According to the optical information recording/regenerating device of the sixty-seventh aspect of the present invention, as the tracking error signal is detected by a common optical system independently of the objective lenses, it has the effect that the optical system is simplified and can be made at a low price.

[0155] It is an object of the present invention to obtain an objective lens driving device and an optical information recording/regenerating device in which a plurality of

objective lenses can be selectively disposed in a single beam to be applicable to optical information recording media with different substrate thicknesses and recording densities, with a simple structure and a small number of parts, and of low price and small size.

[0156] It is another object of the present invention to obtain an optical information recording/regenerating device having a plurality of objective lenses which can effectively apply a laser beam from a light source onto an optical information recording medium.

[0157] It is still another object of the present invention to obtain an optical information recording/regenerating device which can apply the most suitable amount of laser beam to an optical information recording medium.

[0158] It is still another object of the present invention to obtain an optical information recording/regenerating device which is capable of stable regeneration on the basis of signal detected from a reflected light from various kinds of optical information recording media.

[0159] These and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0160] Fig.1 is a perspective view showing an objective lens driving device in a first preferred embodiment of the present invention.

[0161] Fig.2 is an exploded perspective view showing the objective lens driving device in the first preferred embodiment of the present invention.

[0162] Fig.3 is a plan view showing the objective lens driving device in the first preferred embodiment of the present invention.

[0163] Fig.4 is a diagram showing the positional relation among the objective lenses, the lens holder and the optical information recording medium in the objective lens driving device of the first preferred embodiment of the present invention.

[0164] Fig.5 is a diagram showing the relation between the rotation angle of the lens holder and the restoring force occurring in the tracking direction in the objective lens driving device of the first preferred embodiment of the present invention.

[0165] Fig.6 is an exploded perspective view showing an objective lens driving device in a second preferred embodiment of the present invention.

[0166] Fig.7 is a plan view showing the objective lens driving device in the second preferred embodiment of the present invention.

[0167] Fig.8 is a diagram showing the relation between the rotation angle of the lens holder and the restoring force occurring in the tracking direction in the objective lens driving device of the second preferred embodiment of the present invention.

[0168] Fig.9 is a plan view showing an objective lens driving device of a third preferred embodiment of the present invention.

[0169] Fig.10 is a plan view showing an objective lens driving device of a fourth preferred embodiment of the present invention.

[0170] Fig.11 is a plan view showing the objective lens driving device in the fourth preferred embodiment of the present invention.

[0171] Fig.12 is a plan view showing an objective lens driving device in a fifth preferred embodiment of the present invention.

[0172] Fig.13 is a plan view showing an objective lens driving device in a sixth preferred embodiment of the present invention.

[0173] Fig.14 is a plan view showing an objective lens driving device in a seventh preferred embodiment of the present invention.

[0174] Fig.15 is a perspective view showing an objective lens driving device in an eighth embodiment.

[0175] Fig.16 is an exploded perspective view showing the objective lens driving device in the eighth embodiment.

[0176] Fig.17 is a perspective view showing an objective lens driving device in a ninth embodiment.

[0177] Fig.18 is a perspective view showing an objective lens driving device in a tenth preferred embodiment of the present invention.

[0178] Fig.19 is an exploded perspective view showing an objective lens driving device in an eleventh embodiment.

[0179] Fig.20 is a perspective view showing an objective lens driving device in a twelfth preferred embodiment of the present invention.

[0180] Fig.21 is a plan view showing the objective lens driving device in the twelfth preferred embodiment of the present invention.

[0181] Fig.22 is an exploded perspective view showing the objective lens driving device in the twelfth preferred embodiment of the present invention.

[0182] Fig.23 is an exploded perspective view of the movable portion of the objective lens driving device in the twelfth preferred embodiment of the present invention.

[0183] Fig.24 is a perspective view showing the movable portion of the objective lens driving device seen from the back in the twelfth preferred embodiment of the present invention.

[0184] Fig.25 is a diagram showing the relation between the objective lenses and the disk motor and the turntable holding the optical information recording medium of the objective lens driving device in the twelfth preferred embodiment of the present invention.

[0185] Fig.26 is a sectional view of the important part of the objective lens driving device in the twelfth preferred embodiment of the present invention.

[0186] Fig.27 is a perspective view of an important part of an optical information recording/regenerating device having the objective lens driving device in the

twelfth preferred embodiment of the present invention.

[0187] Fig.28 is a diagram showing the structure of the optical information recording/regenerating device.

[0188] Fig.29(a) and Fig.29(b) are diagrams for illustrating an example of means for determining a kind of the optical information recording medium.

[0189] Fig.30 is a perspective view showing a movable portion of an objective lens driving device in a thirteenth preferred embodiment of the present invention.

[0190] Fig.31 is a perspective view of the movable portion of an objective lens driving device seen from the back in a fourteenth preferred embodiment of the present invention.

[0191] Fig.32 is a perspective view showing a fixing base of an objective lens driving device in a fifteenth preferred embodiment of the present invention.

[0192] Fig.33 is a perspective view of a fixing base of an objective lens driving device in a sixteenth preferred embodiment of the present invention.

[0193] Fig.34 is a perspective view showing a movable portion of an objective lens driving device in a seventeenth preferred embodiment of the present invention.

[0194] Fig.35 is a perspective view showing a movable portion of an objective lens driving device in an eighteenth preferred embodiment of the present invention.

[0195] Fig.36 is a perspective view showing a movable portion of an objective lens driving device in a nineteenth preferred embodiment of the present invention.

[0196] Fig.37 is a perspective view showing a movable portion of an objective lens driving device in a twentieth preferred embodiment of the present invention.

[0197] Fig.38 shows an optical information recording/regenerating device having the objective lens driving device in the twentieth preferred embodiment of the present invention.

[0198] Fig.39 is a perspective view of an objective lens driving device in a twenty-first preferred embodiment of the present invention.

[0199] Fig.40 is a plan view of the objective lens driving device in the twenty-first preferred embodiment of the present invention.

[0200] Fig.41 is a perspective view of the movable portion of the objective lens driving device seen from the back in the twenty-first preferred embodiment of the present invention.

[0201] Fig.42 is a perspective view of an important part of an optical information recording/regenerating device having the objective lens driving device in the twenty-first preferred embodiment of the present invention.

[0202] Fig.43 is a diagram illustrating the operation of the optical information recording/regenerating device in the twenty-first preferred embodiment of the present invention.

[0203] Fig.44 is a diagram showing the optical information recording/regenerating device in the twenty-first preferred embodiment of the present invention.

[0204] Fig.45 is a diagram showing an optical system and a block circuit of an optical information recording/regenerating device in a twenty-second preferred embodiment of the present invention.

[0205] Fig.46 is a sectional view showing the important part of the objective lens driving device in the twenty-second preferred embodiment of the present invention.

[0206] Fig.47(A) and Fig.47(B) are side views showing the relation between the optical information recording media and the objective lenses in the twenty-second preferred embodiment of the present invention.

[0207] Fig.48(A) and Fig.48(B) are regeneration signal diagrams obtained when information is regenerated with different optical information recording media with switched objective lenses in the twenty-second preferred embodiment of the present invention.

[0208] Fig.49 is a current-optical output characteristic diagram of a semiconductor laser.

[0209] Fig.50 is a circuit diagram showing the structure of the semiconductor laser.

[0210] Fig.51 is a block circuit diagram showing the structure of a high frequency superposition circuit of the twenty-second preferred embodiment.

[0211] Fig.52 is a current-optical output characteristic diagram of the semiconductor laser with presence/absence of high frequency superposition.

[0212] Fig.53 is a current-optical output characteristic diagram of the semiconductor laser when the high frequency superposition is made large.

[0213] Fig.54 is a diagram showing an optical system and a block circuit of an optical information recording/regenerating device in a twenty-third preferred embodiment of the present invention.

[0214] Fig.55 is a block diagram showing a current-voltage converting circuit of a twenty-fourth preferred embodiment of the present invention.

[0215] Fig.56(A), Fig.56(B) and Fig.56(C) are tracking error signal diagrams obtained when regeneration is applied to different optical information recording media in a twenty-fifth preferred embodiment of the present invention.

[0216] Fig.57 is a block diagram showing the structure of a high frequency superposition circuit in a twenty-sixth preferred embodiment of the present invention.

[0217] Fig.58 is a diagram showing an optical system and a block circuit of an optical information recording/regenerating device in a twenty-seventh preferred embodiment of the present invention.

[0218] Fig.59 is a plan view and a circuit connection diagram of an optical system showing an optical information recording/regenerating device in a twenty-eighth preferred embodiment of the present invention.

[0219] Fig.60(a) and Fig.60(b) are plan views showing an important part of the optical system emitting a laser beam in the twenty-eighth preferred embodiment of the present invention.

[0220] Fig.61(a) and Fig.61(b) are plan views showing the relation between the optical information record-

100A in the second preferred embodiment of the present invention. and Fig.8 is a diagram showing the relation between the rotation angle of the lens holder and the restoring force occurring in the tracking direction in the objective lens driving device 100A in the second preferred embodiment of the present invention. In the figures, the same reference characters are allotted to the same or corresponding parts as to those in Fig.1-Fig. 5, Fig.67-Fig.70.

[0250] Here, 17a, 17b, 17c. 17d are magnetic pieces, which are fixed to the lens holder in the polarization direction of the tracking magnets.

<2-2. Device Operation>

[0251] Next, the operation will be described. Differences of optical information recording medium (not shown) are detected by means for detecting differences in thickness, recording density, etc. of the medium, and a corresponding objective lens is selected. (The objective lens 4 in Fig.7.) Then, the objective lens 4 is disposed in the light beam 2 by the means shown in the first preferred embodiment. When the objective lens 4 is located almost in the center of the light beam, the magnetic pieces 17b, 17c are located almost in the center of the tracking magnets 107a and 107b (at the point with the maximum magnetic flux density), and the magnetic pieces 17a and 17d are located where almost no magnetic field of the tracking magnets exists. When an optical information recording medium with different substrate thickness and recording density is set, the objective lens 3 is selected, and when the objective lens 3 is located almost in the center of the light beam 2, the magnetic pieces 17a and 17d are located almost in the center of the tracking magnets 107a and 107b, and the magnetic pieces 17b and 17c are located where almost no magnetic field of the tracking magnets exists.

[0252] When one of the objective lenses is selected, one set of the magnetic pieces is located to face the tracking magnets, so that a predetermined center point restoring force is generated. This is the same when the other objective lens is selected, but the center point restoring force is not generated during the operation of selecting an objective lens because any set of the magnetic pieces is not located between the tracking magnets.

[0253] Accordingly, if the axis of abscissas indicates the moved angle of the objective lens and the axis of ordinates indicates the center point restoring force, the rotation angle of the lens holder and the restoring force has a relation as shown in Fig.8. Other operations are the same as those shown in the first preferred embodiment.

<3. Third Preferred Embodiment>

<3-1. Device Structure>

[0254] Fig.9 is a plan view showing an objective lens driving device 100B in a third preferred embodiment of the present invention. In the figure, the same reference characters are allotted to the same or corresponding parts in Fig.1-Fig.8, Fig.67-Fig.70.

[0255] The reference characters 21a and 21b are fins projecting from the lens holder 6, and 22 is a wall provided on the fixing base 1.

<3-2. Device Operation>

[0256] Next, the operation will be described. When an optical information recording medium is set in the optical information recording/regenerating device, means not shown distinguishes differences in substrate thickness and recording density of the medium and an objective lens corresponding to that kind of medium is selected. When the selected objective lens does not exist in the light beam 2, the lens holder 6 is rotated around the supporting shaft 103 with an electromagnetic force to move the corresponding objective lens into the light beam 2. At this time, if the objective lens is turning more than needed, the fin 21a (or the fin 21b when it turns in the opposite direction) provided on the lens holder 6 comes in contact with the wall 22 to limit further turn. Other operations are the same as those described in the first or second preferred embodiment of the present invention.

<4. Fourth Preferred Embodiment>

<4-1. Device Structure>

[0257] Fig.10 and Fig.11 are plan views showing an objective lens driving device 100C in a fourth preferred embodiment of the present invention. In the figures, the same reference characters are allotted to the same or corresponding parts in Fig.1-Fig.9, Fig.67-Fig.70.

[0258] The reference character 31 is a fin projecting from the bottom of the lens holder 6, and 32 is a position detecting sensor provided on the fixing base 1 to be located under the lens holder 6.

<4-2. Device Operation>

[0259] Next, the operation will be described. When an optical information recording medium is set in the optical information recording/regenerating device, means not shown distinguishes differences in substrate thickness and recording density of the medium and an objective lens corresponding to that kind of medium is selected. When the selected objective lens does not exist in the light beam 2, the lens holder 6 is rotated around the supporting shaft 103 with an electromagnetic force to move the corresponding objective lens into the light beam 2.

When the objective lens 3 is selected, the fin 31 is located inside the position detecting sensor 32. On the other hand, when the objective lens 4 is selected, the fin 31 is located out of the position detecting sensor 32. Accordingly, it can be detected from output of the position detecting sensor 32 which of the objective lenses is currently selected. Other operations are the same as those in the first preferred embodiment, the second preferred embodiment, or the third preferred embodiment of the present invention.

<5. Fifth Preferred Embodiment>

<5-1. Device Structure>

[0260] Fig.12 is plan view showing an objective lens driving device 100D in a fifth preferred embodiment of the present invention. In the figure, the same reference characters are allotted to the same or corresponding parts in Fig.1-Fig.11, Fig.67-Fig.70.

[0261] The reference character 41 is a fin projecting from the bottom of the lens holder 6, and 42, 43 are a light source and 2-segment photodetector located under the lens holder 6 and provided on the fixing base 1 with the fin 41 interposed therebetween.

<5-2. Device Operation>

[0262] Next, the operation will be described. When the lens holder 6 turns around the supporting shaft 103, the fin portion 41 of the lens holder 6 moves and then the amount of light incident upon respective parts of the photodetector 43 divided in the direction vertical to the track of the optical information recording medium varies according to the moved amount. The turning position of the lens holder 6 can be obtained on the basis of signal output of the 2-segment photodetector 43. On the basis of the information, it can be detected which objective lens is currently selected. Other operations are the same as those in the first preferred embodiment the second preferred embodiment, or the third preferred embodiment of the present invention.

[0263] Furthermore, it is also possible to electrically provide a restoring force to the objective lenses on the basis of the signal output of the 2-segment photodetector 43.

<6. Sixth Preferred Embodiment>

<6-1. Device Structure>

[0264] Fig.13 is a plan view showing an objective lens driving device 100E in a sixth preferred embodiment of the present invention. In the figure, the same reference characters are allotted to the same or corresponding parts in Fig.1-Fig.12, Fig.67-Fig.70.

[0265] The reference characters 51a, 51b, 51c and 51d are tracking coils fixed to the lens holder 6 and 52a, 52b, 52c and 52d are magnetic pieces fixed to the lens holder 6, placed on the tracking coils.

<6-2. Device Operation>

[0266] Next, the operation will be described. When an optical information recording medium is set in the optical information recording/regenerating device, means not shown distinguishes differences in substrate thickness and recording density of the medium and an objective lens corresponding to each kind of medium is selected. The tracking coils 51a and 51c are disposed to face the tracking magnets 107a and 107b when the objective lens 3 is selected. Accordingly, at that time, the lens holder is turned by the electromagnetic interaction of the tracking coils 51a, 51c and the tracking magnets 107a, 107b. When the objective lens 4 is selected, the tracking coils 51b, 51d are disposed to face the tracking magnets 107a, 107b, and the lens holder is turned by the electromagnetic interaction of the tracking coils 51b, 51d and the tracking magnets 107a, 107b.

[0267] A restoring force is provided to the lens holder by the magnetic pieces 52a and 52c when the objective lens 3 is selected, and by the magnetic pieces 52b and 52d when the objective lens 4 is selected. Other operations are the same as those in the first preferred embodiment or in the second preferred embodiment of the present invention.

[0268] In the controlling operation, current may be applied to all of the tracking coils 51a, 51b, 51c and 51d, or coils to be supplied with current may be selectively switched.

<7. Seventh Preferred Embodiment>

<7-1. Device Structure>

[0269] Fig.14 is a plan view showing an objective lens driving device 100F in a seventh preferred embodiment of the present invention. In the figure, the same reference characters are allotted to the same or corresponding parts in Fig.1-Fig.13, Fig.67-Fig.70.

[0270] The reference character 61 denotes a magnet provided on the fixing base 1 and bipolar-magnetized in the width direction.

<7-2. Device Operation>

[0271] Next, the operation will be described. When an optical information recording medium is set in the optical information recording/regenerating device, means not shown distinguishes differences in substrate thickness and recording density of the medium and an objective lens corresponding to that kind of medium is selected. When the selected objective lens does not exist in the light beam 2, the lens holder 6 is rotated around the supporting shaft 103 with an electromagnetic force to move the corresponding objective lens into the light beam 2.

At that time, current is also passed to the tracking coil facing the magnet 61 in addition to the tracking coil facing the tracking magnets 107a, 107b to produce a driving force. Other operations are the same as those in the sixth preferred embodiment of the present invention.

<8. Eighth Preferred Embodiment>

<8-1. Device Structure>

[0272] Fig.15 is a perspective view showing an objective lens driving device 100G in an eighth embodiment and Fig.16 is an exploded perspective view of the objective lens driving device 100G in the eighth embodiment. In the figures, the same reference characters are allotted to the same or corresponding portions in Fig. 1-Fig.14, Fig.67-Fig.70.

[0273] The reference character 71 denotes a lens holder formed of a plastic material, or the like, with light weight and high toughness, which holds a plurality of objective lenses in positions almost symmetrical about the supporting shaft 103. The lens holder 71 is provided with a bearing portion having its axis almost parallel to the optical axes of the objective lenses 3 and 4.

[0274] The reference character 72 denotes a ring-like magnet fixed to the lens holder 71 coaxially with the bearing portion, which is, for example, a magnet multipolar-magnetized in the diameter direction like a motor.

[0275] The reference character 73 is a focusing coil fixed to the supporting shaft holding base 5, which is disposed in a magnetic circuit formed of the magnet 72 and the supporting shaft holding base 5. 74a and 74b denote tracking coils fixed on the fixing base 1, which are disposed in a magnetic circuit formed of the magnet 72 and the fixing base 1.

<8-2. Device Operation>

[0276] Next, the operation will be described. While the magnet is provided on the fixed side and the coil on the movable side is supplied with current to achieve movement of an objective lens corresponding to each medium, focusing control, and tracking control in the first preferred embodiment of the present invention, the coil is provided on the fixed side and the magnet is provided on the movable side in the eighth embodiment, where the lens holder 71 is rotated by 180° to switch the objective lenses 3 and 4 to adapt to different optical information recording media. Other operations are the same.

<9. Ninth Preferred Embodiment>

<9-1. Device Structure>

[0277] Fig. 17 is a perspective view showing an objective lens driving device 100H in a ninth embodiment. In the figure, the same reference characters are allotted to the same or corresponding parts in Fig.1-Fig.16, Fig. 67-Fig.70.

[0278] The reference character 81 denotes a sending up mirror which reflects the light beam 2 in a direction almost parallel to the optical information recording medium surface, which is disposed to be turnable in the direction of the arrow T by driving means not shown. The reference character 82 is also a sending up mirror which reflects the light beam 2 in the direction almost parallel to the optical information recording medium surface, and 83 and 84 are sending up mirrors which direct the light beam 2 in the vertical direction.

<9-2. Device Operation>

[0279] Next, the operation will be described. When an optical information recording medium is set in the optical information recording/regenerating device, means not shown distinguishes the differences in substrate thickness and recording density of the medium and an objective lens corresponding to each kind of medium is selected. When the objective lens 3 is selected, the light beam 2 is reflected at the mirror 81 and is further reflected in the vertical upward direction at the mirror 83 to enter the objective lens 3, and then it forms a light spot on the optical information recording medium. Operations after that are the same as those in the eighth embodiment.

[0280] When the objective lens 4 is selected, the mirror 81 is turned in the direction of the arrow T by driving means not shown to withdraw from in the light beam, so that the light beam 2 goes straight forward. Then, the light beam 2 is reflected at the mirror 82, and further led up by the mirror 84 in the vertical upward direction to enter the objective lens 4, thus forming a light spot on the optical information recording medium. As it has movable mirrors 81 and 82 and also has the mirrors 83 and 84 in correspondence to the objective lenses 3 and 4, it is not necessary to turn the lens holder 71.

<10. Tenth Preferred Embodiment>

<10-1. Device Structure>

[0281] Fig.18 is a perspective view showing an objective lens driving device 100I in a tenth preferred embodiment of the present invention. In the figure, the same reference characters are allotted to the same or corresponding parts in Fig.1-Fig.17, Fig.67-Fig.70.

[0282] The reference character 1f denotes a spring supporting stand provided on the fixing base 1. The reference characters 91a and 91b denote plate springs each having one end fixed to the spring supporting stand 1f, extending almost parallel to the optical information recording medium surface, and disposed so that the lens holder 93 is vertically interposed therebetween. 92 denotes a pivot bearing provided on the plate springs 91a and 91b for supporting the lens holder 93 turnably.

<10-2. Device Operation>

[0283] Next, the operation will be described. As the plate springs 91a and 91b are structured as described above, lens holder 93 is moved in the vertical direction almost parallel to the optical axis of the objective lens by the electromagnetic force when desired current is applied to the focusing coil 119 to perform focusing control.

[0284] When a desired current is applied to the tracking coils 121a and 121b, lens holder 93 turns around the pivot bearing with the electromagnetic force to perform tracking control and to move the corresponding objective lens into the light beam. Other operations are the same as those in the first preferred embodiment.

[0285] Although the above-described preferred embodiment has shown the structure in which the lens holder is interposed between the plate springs through the pivot bearing, it is needless to say that the same effects are obtained with a structure in which the spring supporting stand itself is pinched by the fixing base through a pivot bearing with the plate springs fixed to the lens holder, the spring supporting stand itself being rotatable around the pivot bearing, with a plurality of objective lenses provided at almost equal distances from the pivot bearing.

<11. Eleventh Preferred Embodiment>

<11-1. Device Structure>

[0286] Fig.19 is an exploded perspective view showing an objective lens driving device 100J in an eleventh embodiment . In the figure, the same reference characters are allotted to the same or corresponding parts in Fig.1-Fig.17, Fig.67-Fig.70.

[0287] The reference characters 151a and 151b denote magnets, 152a and 152b denote yokes, 153a, 153b, 153c and 153d denote hollow and cylindrical rubber dampers, and 154a denotes a wire provided in the rubber damper 153a. In Fig.19, to clearly show the wire 154a, the rubber damper 153a is partially removed. Similarly, wires 154b-154d are provided in the rubber dampers 153b-153d, but which are not shown. 155 is a supporting plate and 156a and 156b are objective lens holders. 119 is a focusing coil wound around the outer wall surface of the box-like objective lens holder 156b, and 121a-121d are tracking coils disposed upon the focusing coil 119.

<11-2. Device Operation>

[0288] Next, the operation will be described. When predetermined current is passed through the tracking coils 121a-121d and the focusing coil 119, the holders 156a, 156b are moved up and down and right and left with the interaction of the magnets 151a, 151b and the yokes 152a, 152b, and the tracking error and the focusing error of the objective lenses 3 and 4 provided on the objective lens holder 156a can be corrected. When the objective lenses 3 and 4 are selected according to kinds of the optical information recording media as in other preferred embodiments, the same effects are obtained.

<12. Twelfth Preferred Embodiment>

<12-1. Device Structure>

[0289] Fig.20 is a perspective view showing an objective lens driving device 100K in a twelfth preferred embodiment of the present invention, and Fig.21 is a plan view showing the objective lens driving device 100K in the twelfth preferred embodiment of the present invention, which shows a lens holder described later partially in a perspective view. Fig.22 is an exploded perspective view showing the objective lens driving device 100K in the twelfth preferred embodiment of the present invention, Fig.23 is an exploded perspective view of the movable portion of the objective lens driving device 100K in the twelfth preferred embodiment of the present invention, and Fig.24 is a perspective view seen from the back of the movable portion of the objective lens driving device 100K in the twelfth preferred embodiment of the present invention. Fig.25 is a diagram showing the relation between the objective lenses and the disk motor and the turntable holding the optical information recording medium of the objective lens driving device 100K in the twelfth preferred embodiment of the present invention. Fig.26 is a sectional view showing an important part of the objective lens driving device 100K in the twelfth preferred embodiment of the present invention. Fig.27 is a perspective view of an important part of an optical information recording/regenerating device having the objective lens driving device 100K of the twelfth preferred embodiment of the present invention, and Fig.28 is a diagram showing the structure of the optical information recording/regenerating device in the twelfth preferred embodiment of the present invention. Fig.29 is a diagram illustrating a method of distinguishing kinds of the optical information recording media.

[0290] In Fig.20 to Fig.26, 301 is a first fixing base formed of a magnetic material, which has projections P1 and P2 having screw portions 301a and 301b. It also has a projection P3 and a through hole 301c in the vicinity of the bottom in the direction almost opposite to the sum of the vector directed from the supporting shaft 304 to 301a and the vector directed to 301b. Also, a spherical portion 301d is provided as shown in Fig.26 in the bottom of the first fixing base 301. As shown in Fig. 26, the center of the spherical portion 301d is provided in the vicinity of the intersection of a plane parallel to the optical information recording medium including the principal point of the objective lens and the axis line. 302 is a light beam.

[0291] The reference character 303 denotes a second fixing base, which holds the lower end of the supporting shaft 304 coated with fluororesin with a small frictional

coefficient. 305 and 306 are focusing magnets magnetized in the direction parallel to the optical information recording medium, which are bonded and fixed to the second fixing base 303. As shown in Fig.26, the portion where the spherical portion 301d is formed in the first fixing base 301 forms a step sinking from the portion around it, and the second fixing base 303 is bonded and fixed utilizing this step. The height of this step is equal to or larger than the thickness of the bottom of the second fixing base 303.

[0292] The reference characters 307 and 308 are tracking magnets bipolar-magnetized in the right and left direction, which are bonded and fixed to the first fixing base 301. 309 is a sending up mirror which reflects in the vertical direction the light beam 302 incident from the front.

[0293] The reference character 310 is a lens holder formed of a plastic material with light weight and high stiffness, for example, which holds the objective lenses 311 and 312 corresponding to a plurality of optical information recording media with different substrate thicknesses in positions eccentrically displaced from the supporting shaft 304 by almost equal distances so that the two are positioned as close as possible. The lens holder 310 is provided with a bearing portion having its center axis almost parallel to the optical axes of the objective lenses 311 and 312.

[0294] As shown in Fig.25, when the objective lenses 311 and 312 corresponding to generally different kinds of optical information recording media are provided in positions where they condense the light beam 2 onto the optical information recording media, the distances from the lower surface of the media (called working distances) W1 and W2 differ. 313 is a disk-like optical information recording medium, 314 is a disk motor which rotates the optical information recording medium, and 315 is a turntable which holds the optical information recording media rotatable. The objective lenses 311 and 312 are bonded and fixed to the lens holder 310 so that one having a larger working distance is positioned closer to the turntable 315, i.e., positioned in the inner side of the optical information recording medium.

[0295] The objective lenses 311 and 312 corresponding to generally different kinds of optical information recording media have different outside diameters. The objective lenses 311 and 312 are bonded and fixed to the lens holder 310 so that one having a smaller outside diameter is positioned closer to the turntable 315, i.e., in the inner side of the optical information recording medium.

[0296] The reference numeral 316 is a focusing coil which is bonded and fixed to the lens holder 310 coaxially with the bearing portion, which is disposed in the magnetic gap formed by the second fixing base 303 and the focusing magnets 305 and 306.

[0297] The lens holder 310 has four notch portions NP, into which magnetic pieces 317a, 317b, 317c and 317d are inserted and bonded to be fixed. The positions where the magnetic pieces 317a and 317b, and 317c and 317d are fixed are disposed at the almost same angle as the angle between the objective lenses 311 and 312 about the supporting shaft 304, respectively. The positions where the magnetic pieces 317a and 317c, and 317b and 317d are fixed are disposed at the almost same angle as the angle between the tracking magnets 307 and 308 about the supporting shaft 304, respectively.

[0298] Furthermore, tracking coil fixing bosses TB are formed in the lens holder 310 across the notches. The tracking coils 318a, 318b, 318c, and 318d are positioned to the tracking coil fixing bosses TB, and bonded and fixed. The positions where the tracking coils 318a and 318b, and 318c and 318d are fixed are disposed at the almost same angle as the angle between the objective lenses 311 and 312 about the supporting shaft 304. The positions where the tracking coils 318a and 318c, and 318b and 318d are fixed are disposed at the almost same angle as the angle between the tracking magnets 307 and 308 about the supporting shaft 304, respectively. The tracking coils 318a-318d are formed by continuous winding, which are connected in series. The line length between each tracking coil is set longer than the distance between the tracking coil fixing bosses TB.

[0299] A projection 319 is provided on the back of the lens holder 310. The projection 319 is disposed at a position so that it gets in contact with the second fixing base 303 when the lens holder 310 turns.

[0300] The reference character 320 denotes power supplying means for supplying driving current to the focusing coil and the tracking coil provided on the lens holder 310, which is formed of a flexible printed wiring board using a flexible insulating board. The power supplying means 320 is divided into the power supplying means 320a and 320b, whose ends are positioned and fixed in the vicinity of the center of gravity of the movable portion in the vicinity of the upper end of the cylindrical portion holding the focusing coil provided on the back of the lens holder 310 and electrically connected to end lines of the focusing coil and the tracking coil by soldering, or the like. The lens holder 310 has a projection 321c, which is for drawing the end line so that it will not intercept the hole for passage of the light beam.

[0301] Bosses 321a and 321b integrally formed with the lens holder are provided in the periphery of the portion where the power supplying means 320 is fixed. The other end of each power supplying means 320a, 320b is positioned and fixed at the boss BS provided on the side wall of the first fixing base 301. Furthermore, the power supplying means 320a and 320b are formed almost symmetrical with respect to the line connecting the supporting shaft 304 and the center between the objective lenses 311 and 312. The power supplying means 320 is formed to have a plane in the direction vertical to the optical information recording medium.

[0302] The reference character 331 is a special screw having a screw at its end and a cylindrical portion with

a diameter larger than that of the screw portion, 332 is a spring, and 333 and 334 are screws.

<12-2. Device Operation>

[0303] Next, the operation will be described. When an optical information recording medium is set in the optical information recording/regenerating device, distinguishing means not shown distinguishes the kind of the optical information recording medium and an objective lens corresponding to that kind is selected (the objective lens 312 in Fig.21).

[0304] Here, an example of distinguishing the optical information recording medium will be described using Fig.29. Fig.29 shows a method in which a kind of an optical information recording medium is distinguished by determining if a corresponding objective lens is selected or not when the optical information recording medium is set.

[0305] As shown in Fig.29(a), when an objective lens corresponding to the set optical information recording medium is selected, the focusing error signal has an amplitude not less than a predetermined threshold, but if an objective lens not corresponding to the set optical information recording medium is selected, an amplitude just not more than the threshold is obtained as shown in Fig.29(b). Accordingly, by comparing the amplitude of the focusing error signal with a set threshold, it can be determined whether a correct objective lens is selected or not. This method is disclosed in detail in Japanese Patent Laying-Open No.7-98431, so further explanation is not made herein.

[0306] Although the method of automatically distinguishing an optical information recording medium with distinguishing means was shown in the description above, it is not restricted to the automatic distinguishment as long as the distinguished result is provided as electric signal. That is to say, an operator of the optical information recording/regenerating device may set the kind of an optical information recording medium with a switch, button or the like and the electric signal may be provided to the objective lens driving device. Then, an objective lens is selected according to the optical information recording medium of the kind set by the operator.

[0307] When the objective lens corresponding to the optical information recording medium exists in the light beam 302, focusing adjusting operation is continuously started. When the corresponding objective lens does not exist in the light beam 302, predetermined current is applied to the tracking coils 318a-318d to turn the lens holder 310 around the supporting shaft 304 with the electromagnetic force obtained by the interaction with the magnetic field produced by the tracking magnets 307 and 308 to move the corresponding objective lens into the light beam 302. At this time, the selected objective lens diaphragms turn in the vicinity of the center of the light beam because of the magnetic force produced by magnetic pieces described later and that position is held. Then, focusing adjusting operation is started.

[0308] When a focusing error of a light spot (not shown) is corrected, desired current is applied to the focusing coil 316 to drive the lens holder 310, in turn the objective lens 311 or 312 in the direction vertical to the optical information recording medium with the electromagnetic force obtained by the interaction with the magnetic field produced by the focusing magnets 305 and 306 to achieve control in the focusing direction. When a tracking error of the light spot (not shown) is corrected, predetermined current is applied to the tracking coils 318a-318d to turn the lens holder 310 around the supporting shaft 304 in the direction across the track of the optical information recording medium with the electromagnetic force obtained by the interaction with the magnetic field produced by the tracking magnets 307 and 308 to control the objective lens 311 or 312 in the tracking direction.

[0309] The magnetic pieces 317a-317d are disposed in positions where the magnetic flux density is highest in the magnetic field produced by the tracking magnets 307 and 308 when the plurality of objective lenses provided on the lens holder 310 are respectively in the center position of the light beam 302. The magnetic flux density applied to the magnetic material varies as the lens holder 310 moves either in the focusing direction or the tracking direction, and a restoring force is magnetically caused according to the moved amount. Shapes of the magnetic pieces 317a-317d are determined so that linear characteristics are obtained in the range in which track correction of the objective lenses is made (generally about ±0.5 mm).

[0310] As the power supplying means 320 is fixed in the vicinity of the center of gravity of the movable portion including the lens holder 310, the repulsion force produced by the power supplying means 320 does not affect the driving of the lens holder even if the lens holder moves. Furthermore, the power supplying means 320 provides damping effect of the movable portion. The bosses 321a and 321b integrally formed with the lens holder 310 restrict the moved amount of the power supplying means 320 and prevent it from peeling off the fixed portion.

[0311] The first fixing base 301 is pressed by the special screw 331 and the spring 332 so that the spherical portion 301d and a conical surface of a head base 40 described later are in contact. By adjusting the amount of tightening of the screw 334 inserted from the head base 40 side, the inclination of the optical axis of the first fixing base 301, and in turn, of the objective lenses 311 and 312 in the track direction of the optical information recording medium can be adjusted around the center point of the spherical portion 301d. Similarly, by adjusting the amount of tightening of the screw 333, the inclination of the optical axis of the first fixing base 301, and in turn, of the objective lenses 311 and 312 in the direction vertical to the track of the optical information recording medium can be adjusted.

[0312] In Fig.27 and Fig.28, 340 denotes an optical head base, 341 is a semiconductor laser as a light source, which is positioned and fixed to the optical head base 340. 342 is a diffraction grating for splitting the light beam, which is bonded and fixed to a diffraction grating holder 343, and the diffraction grating holder 343 is positioned and fixed rotation-adjustably to the optical head base 340. 344 is a half mirror having a property of reflecting part of incident light beam and transmitting part of it, which is positioned and fixed to the optical head base 340. 345 is a collimator lens having a property of converting divergent light into an almost parallel light beam, which is also positioned and fixed to the optical head base 340. 346 is a convergent lens which condenses the light beam and produces astigmatism to generate the focusing error signal. The convergent lens 346 is bonded and fixed to a convergent lens holder 347, and the convergent lens holder 347 is positioned and fixed to the optical head base 340 to be adjustable in the light beam direction. 348 is a photodetector, which has a function of converting the incident light into current according to the light amount. The optical head base 340 has a bearing 351 and a U-shaped portion 352, which is supported by a shaft not shown, and is driven in the direction of the radius of the optical information recording medium by driving means not shown.

[0313] The light beam emitted from the semiconductor laser 341 is divided into three beams at the diffraction grating 342, and then reflected by the half mirror 344. The light beam is then converted into parallel light by the collimator lens 345, reflected by the mirror 309 to be incident upon the objective lens provided in the objective lens driving device, and is condensed upon the optical information recording medium. The light beam reflected at the optical information recording medium is transmitted through the half mirror 344 and passed through the convergent lens 346. and then impinges upon the photodetector 348. The current outputted from the photodetector 348 is converted into a voltage at the current-voltage converting circuit 390 and then a regeneration signal is detected by a regeneration signal detecting circuit 394, and the focusing error signal and the tracking error signal are produced by a focusing error detecting circuit 392 and a tracking error detecting circuit 393, on the basis of which the driving device driving circuit 396 is provided with necessary information to drive the objective lens driving device. Furthermore, on the basis of the signal obtained from the photodetector 348, disk distinguishing means 391 distinguishes the optical information recording medium, and predetermined ourrent (voltage) is generated by a switch pulse generating circuit 395 if needed and is inputted to the driving device driving circuit 396, and then the lens holder 310 is turned to select the objective lens.

[0314] The magnetic materials 317a-317d are fixed to the lens holder 310 in the above-described twelfth preferred embodiment, but they may be insert-molded into one with the lens holder 310.

<13. Thirteenth Preferred Embodiment>

[0315] Fig.30 is a perspective view showing a movable portion of an objective lens driving device 100L in a thirteenth preferred embodiment of the present invention. In the figure, the same characters are allotted to the same structures in Figs.20-26 and overlapping description is not repeated here.

[0316] In Fig.30, 361a, 361b, 361c and 361d are cylindrical magnetic pieces, which are manufactured by cutting an existing pin material, for example. The magnetic materials 361a-361d are positioned and fixed to the notch portions NP of the lens holder 310. Other structures, operations and effects are completely the same as those of the objective lens driving device 100K.

<14. Fourteenth Preferred Embodiment>

[0317] Fig.31 is a perspective view of a movable portion of an objective lens driving device 100M seen from the back in a fourteenth preferred embodiment of the present invention. In Fig.31, the same characters are allotted to the same structures in Fig.20-Fig.26, and overlapping description is not repeated here.

[0318] In Fig.31, 362a, 362b are walls projecting around the focusing coil holding portion of the lens holder 310. The power supplying means 320a and 320b are positioned and fixed in the gaps between the focusing coil holding portion and 362a, 362b. Other structures, operations and effects are completely the same as those of the objective lens driving device 100K.

<15. Fifteenth Preferred Embodiment>

[0319] Fig.32 is a perspective view of a fixing base of an objective lens driving device 100N in a fifteenth preferred embodiment of the present invention.

[0320] In Fig.32, 363 denotes a fixing base formed of a magnetic material, which has screw portions 363a, 363b respectively in projections P11 and P12. It also has a through hole 363c formed in a projection P13 in the vicinity of the bottom in the direction almost opposite to the sum of the vector directed from the supporting shaft 304 to the screw portion 363a and the vector to the screw portion 363b. A spherical portion 363d (not shown) is provided on the bottom of the fixing base 363. The center of the spherical portion 363d is provided in the vicinity of the intersection of a plane parallel to the optical information recording medium including the principal point of the objective lens and the axis line. A holding portion H1 for the supporting shaft, a holding portion H2 for the focusing magnet, and a holding portion H3 for the tracking magnet are integrally formed to the fixing base 363. The fixing base 363 is formed of a sintered material containing iron. Other structures, operations, and effects are all the same as those of the objective lens driving device 100K.

<16. Sixteenth Preferred Embodiment>

[0321] Fig.33 is a perspective view of a fixing base of an objective lens driving device 1000 in a sixteenth preferred embodiment of the present invention. In Fig.33, the same characters are allotted to the same structures as those in Fig.32, and overlapping description is not repeated here.

[0322] The reference character 364 denotes a fixing base. While the fifteenth preferred embodiment of the present invention has shown the structure in which the fixing base 363 is formed of a sintered material containing iron, a structure in which it is formed of a sheet metal containing iron is shown in this preferred embodiment.

[0323] As it is formed with a sheet metal, the holding portion H2 for the focusing magnet is formed by bending, and the bent portion of the holding portion H2 for the focusing magnet is a notch portion. Other structures, operations and effects are completely the same as those of the objective lens driving device 100K.

<17. Seventeenth Preferred Embodiment>

[0324] Fig.34 is a perspective view showing a movable portion of an objective lens driving device 100P in a seventeenth preferred embodiment of the present invention. In the figure, the same characters are allotted to the same structures as those in Fig.20 to Fig.26 and overlapping description is not repeated here.

[0325] In Fig.34, the lens holder 310 has bosses BS1 formed at a plurality of positions. 365a, 365b, 365c and 365d are magnetic pieces having rectangular holes in center portions, which are positioned and fixed to the bosses BS1 of the lens holder. Furthermore, the tracking coils 318a-318d are positioned and fixed on them with the same bosses. Other structures, operations and effects are completely the same as those of the objective lens driving device 100K.

<18. Eighteenth Preferred Embodiment>

[0326] Fig.35 is a perspective view showing a movable portion of an objective lens driving device 100Q in an eighteenth preferred embodiment of the present invention. In the figure, the same characters are allotted to the same structures as those in Fig.20 to Fig.26 and overlapping description is not repeated here.

[0327] In Fig.35, the lens holder 310 has a plurality of bosses BS2 having slits in the center. 366a, 366b, 366c and 366d are magnetic pieces, which are positioned and fixed to the slits of the bosses BS2 of the lens holder. Furthermore, tracking coils 318a-318d are positioned and fixed upon them to the bosses BS2. Other structures, operations and effects are completely the same as those of the objective lens driving device 100K.

<19. Nineteenth Preferred Embodiment>

[0328] Fig.36 is a perspective view showing a movable portion of an objective lens driving device 100R in a nineteenth preferred embodiment of the present invention. In the figure, the same characters are allotted to the same structures as those in Fig.20 to Fig.26 and overlapping description is not repeated here.

[0329] In Fig.36, an engagement portion 367 including continuously formed two through holes of circular shape in a plan and of different diameters is provided in the upper surface of the lens holder 310. The objective lenses 311 and 312 are positioned and fixed in this engagement portion 367. Other structures, operations and effects are completely the same as those of the objective lens driving device 100K.

<20. Twentieth Preferred Embodiment>

<20-1. Device Structure>

[0330] Fig.37 is a perspective view showing a movable portion of an objective lens driving device 100S in a twentieth preferred embodiment of the present invention. In the figure, the same structures as those in Fig. 20 to Fig.26 are designated by the same reference characters and overlapping description will not repeated here.

[0331] In Fig.37, tracking coils 368a, 368b, 368c and 368d are positioned and bonded to be fixed to tracking coil fixing bosses TB formed across notches NP of the lens holder 310. The tracking coils 368a and 368c, and 368b and 368d are fixed in positions at an angle almost the same as the angle formed by the objective lenses 311 and 312 about the supporting shaft 304, respectively. The tracking coils 368a and 368b, and 368c and 368d are fixed in positions at an angle almost the same as the angle between the tracking magnets 307 and 308 about the supporting shaft 304, respectively. The tracking coils 368a and 368b, and 368c and 368d are formed by continuous winding, respectively, which are connected in series. The line length between the respective tracking coils is set somewhat longer than the distance between the bosses. The set of the tracking coils 368a and 368b, the set of the tracking coils 368c and 368d are connected to the driving device driving circuit (not shown) in parallel, respectively.

<20-2. Device Operation>

[0332] Next, the operation will be described referring to Fig.38 which shows the structure of an optical information recording/regenerating device in the twentieth preferred embodiment of the present invention. When an objective lens corresponding to an optical information recording medium is selected, a set of the tracking coils positioned to face the tracking magnet is selected using a tracking coil switching circuit 397. A predeter-

mined voltage (current) is applied to the selected set of tracking coils from the driving device driving circuit 396 to drive the objective lens driving device in the tracking direction. Similarly, on the basis of signal obtained from a photodetector, the optical information recording medium is distinguished by disk distinguishing means 391, and a set of tracking coils is selected by the tracking coil switching circuit 397 if needed, and then predetermined current (voltage) is generated by the switching pulse generating circuit 395 and inputted to the driving device driving circuit 396 to rotate the lens holder to select the objective lens. Other structures, operations, and effects are completely the same as those in the twelfth preferred embodiment.

<21. Twenty-first Preferred Embodiment>

<21-1. Device Structure>

[0333] Fig.39 is a perspective view of an objective lens driving device 100T in a twenty-first preferred embodiment of the present invention, Fig.40 is a plan view of the objective lens driving device 100T in the twenty-first preferred embodiment of the present invention, and Fig.41 is a perspective view of the movable portion of the objective lens driving device seen from the back in the twenty-first preferred embodiment of the present invention. Fig.42 is a perspective view of the important portion of an optical information recording/regenerating device having the objective lens driving device 100T in the twenty-first preferred embodiment of the present invention, and Fig.43 is a diagram showing the structure of the optical information recording/regenerating device in the twenty-first preferred embodiment of the present invention. Fig.44 is an external perspective view of the optical information recording/regenerating device in the twenty-first preferred embodiment of the present invention. In the figures, the same reference characters are allotted to the same structures as those in Fig.20 to Fig. 26, and overlapping description is not repeated here.

[0334] In Fig.39 to Fig.44, 371 is a first fixing base formed of a magnetic material. 372, 373, 374 and 375 are tracking magnets bipolar-magnetized in the right and left direction, which are bonded and fixed to the first fixing base 371. The magnets 372 and 373, and 374 and 375 are fixed at positions at an angle almost the same as the angle formed by the objective lenses 311 and 312 about the supporting shaft 304, respectively. The tracking magnets 372 and 374, and 373 and 375 are fixed at positions at an angle almost the same as the angle between tracking coils 377a and 377b described later about the supporting shaft 304. The end of the power supplying means 320 is fixed on the back of the lens holder 310, which is electrically connected to end lines of the focusing coil and the tracking coils 377a and 377b by soldering, or the like.

[0335] The lens holder 310 has notches, into which the magnetic pieces 376a and 376b are inserted and bonded to be fixed. Tracking coil fixing bosses are formed across the notches in the lens holder 310. The tracking coils 377a and 377b are positioned to the tracking coil fixing bosses and fixed by bonding. The tracking coils 377a and 377b are formed by continuous winding, which are connected in series. The connecting line between the two tracking coils is drawn onto the back of the lens holder 310, which is fixed being covered when the power supplying means 320 is fixed to the lens holder. The lens holder 310 has projections 378a and 378b, where the end lines and connecting line are drawn not to intercept the hole for transmission of the light beam.

[0336] In Fig.44, 380 is an optical head device which is an important part of an optical information recording/regenerating device having the objective lens driving device 100T, 381 is a mechanical deck, and 382 is a circuit board, in which various circuits as shown in Fig. 43 are packaged. The reference numeral 383 shows an appearance of the optical information recording/regenerating device, which includes the optical head device 380, the mechanical deck 381 and the circuit board 382 therein.

<21-2. Device Operation>

[0337] Next, the operation will be described. Predetermined current is applied to the tracking coils 377a and 377b to rotatively control the lens holder 310. While the twelfth preferred embodiment of the invention uses four tracking coils and magnetic materials and two tracking magnets, this preferred embodiment uses two tracking coils and magnetic materials and four tracking magnets. Other structures, operations and effects are completely the same as those in the twelfth preferred embodiment.

[0338] As shown in Fig.44, the optical information recording/regenerating device 383 has a change-over switch corresponding to optical information recording media, for example, CD and DVD (Digital Video Disk) so that an operator can manually determine the optical information recording medium species.

<22. Twenty-second Preferred Embodiment>

<22-1. Device Structure>

[0339] Fig.45 is a diagram showing the structure of an optical system and an electric system of an optical information recording/regenerating device 400 in a twenty-second preferred embodiment of the present invention. In the figure, 411 is a semiconductor laser as a light source, and a collimator lens 412, a beam splitter 413 and a mirror 108 are arranged in order in the direction of emission of the semiconductor laser 411. An objective lens driving device 415 is disposed in the direction of reflection of the mirror 108. In the objective lens driving device 415, a lens holder 416 is provided with two objective lenses, an objective lens 403 and an objective lens 404. The reference character 419 is a driving mech-

anism for the objective lens driving device 415 and 420 is an optical information recording medium. Fig.45 shows the laser beam from the semiconductor laser 411 being radiated to the optical information recording medium 420 through the objective lens 403 selected in the reflection direction of the mirror 108.

[0340] Seen from the optical information recording medium 420, a lens 421 and a photodetector 422 are arranged in order in the direction of reflection of the beam splitter 413. Output signal of the photodetector 422 is connected to a current-voltage converting circuit 423. Output signal of the current-voltage converting circuit 423 is connected to a focusing error detecting circuit 424, a tracking error detecting circuit 425 and a regeneration signal detecting circuit 426, respectively.

[0341] The reference character 428 denotes a driving device driving circuit, which has a focusing driving circuit 428a, a tracking driving circuit 428b and a switching pulse circuit 428c. Output of the focusing error detecting circuit 424 is connected to the focusing driving circuit 428a, and output of the tracking error detecting circuit 425 is connected to the tracking driving circuit 428b, respectively. Output of the control device 429 is connected to the switching pulse circuit 428c, and output of the switching pulse circuit 428c is connected to the tracking driving circuit 428b. Output signals of the focusing driving circuit 428a and the tracking driving circuit 428b are connected to the driving mechanism 419.

[0342] The reference character 427 denotes disk distinguishing means for distinguishing kinds of optical information recording media, or optical disks, which outputs distinguishing signal indicating to which of the objective lenses 403 and 404 the used optical disk corresponds.

[0343] Output signal of the disk distinguishing means 427 is connected to the control device 429. The control signal outputted from the control device 429 is connected to the switching pulse circuit 428c, the laser driving circuit 430 and the power supply circuit 31, respectively. Output current from the laser driving circuit 430 is injected into the semiconductor laser 411. The output voltage of the power supply circuit 431 is applied to a high frequency superposition circuit 432 and the output current from the high frequency superposition circuit 432 is injected into the semiconductor laser 411.

[0344] Here, the objective lens driving device 100 shown in Fig.1 is used as the objective lens driving device 415, for example. Accordingly, though overlapping description is not repeated here, the objective lenses 3 and 4 in Fig.1 work as the objective lenses 403 and 404, the lens holder 6 works as the lens holder 416, and the tracking magnets 107a and 107b and the tracking coils 121a and 121b are generically referred to as the driving mechanism 419.

<22-2. Device Operation>

[0345] Next, the operation will be described. The laser beam emitted from the semiconductor laser 411 is led to the objective lens driving device 415 by the optical system. Here, it is first assumed that the objective lens 403 is being selected. When an optical information recording medium 420 adapted for the objective lens 403 is set in the optical information recording/regenerating device, information is recorded or regenerated with the objective lens 403. It is the same as the conventional device that the reflected light of the optical information recording medium 420 is detected at the photodetector 422, its output current is converted into a voltage by the current-voltage converting circuit 423, which is inputted to the regeneration signal detecting circuit to extract signal components, and further, it is also the same as the operation in the conventional device that the focusing error and tracking error signal components are generated from the reflected light of the optical information recording medium 420 as well as the regeneration signal, which are inputted to the driving device driving circuit 428 to cause the objective lens to always follow the optical information recording medium 420.

[0346] Next, if an optical information recording medium which is adapted for the objective lens 404 is set with the objective lens 403 being selected, a signal indicating that the optical information recording medium is adapted for the objective lens 404 is transferred from the disk distinguishing means 427 to the control device 429. The control device 429 transfers a control signal for switching from the objective lens 403 to the objective lens 404 to the switching pulse circuit 428c of the driving device driving circuit 428.

[0347] The switching pulse circuit 428c outputs a switching pulse signal for the objective lens to the tracking driving circuit 428b. The current outputted from the tracking driving circuit 428b is applied to the coil of the driving mechanism 419, and then the lens holder 416 turns to move the objective lens 404 onto the optical axis, which completes switch of lens.

[0348] When an optical information recording medium 420 adapted for the objective lens 403 is set with the objective lens 404 being selected, the same operation achieves switch to the objective lens 403.

[0349] Fig.46 is a sectional view showing an important part of the objective lens driving device 415. The two objective lenses 403 and 404 have different optical characteristics so that they can adapt to different kinds of optical information recording media 420. For example, the objective lens 403 has its aperture diameter c1 and the objective lens 404 has its aperture diameter c2. Now, if the objective lenses 403 and 404 have equal focal length, then the difference in aperture diameter (effective incident diameter of the lens) corresponds to the difference in numerical aperture (a value defied by the ratio of the aperture radius and the focal length of the lens) of the lens.

[0350] By the way, it is known that the size of a condensed light spot formed by an objective lens is in proportion to the wavelength of the light source used, and

is in inverse proportion to the numerical aperture of the lens. As the optical information recording/regenerating device shown in Fig.45 uses a single light source, the wavelength is the same, so the size of the condensed light spot depends on the numerical aperture of the lens. That is to say, an objective lens with larger numerical aperture, in other words, with a larger aperture diameter can form a smaller condensed light spot. Accordingly, with the different aperture diameters of the two objective lenses as shown in Fig.21, as the objective lens 403 can form a smaller condensed light spot than the objective lens 404, the objective lens 403 can be applied to an optical information recording medium with higher density and the objective lens 404 can be applied to an optical information recording medium with a conventional recording density.

[0351] Fig.47 is a side view showing the relation between optical information recording media of different kinds and objective lenses and Fig.47(A) shows the relation between optical information recording media with the same substrate thickness and different recording densities and objective lenses. The reference character 435 denotes an optical information recording medium with high density, to which the objective lens 403 with large aperture diameter is applied. The reference character 436 denotes a conventional optical information recording medium, to which the objective lens 404 with a smaller aperture diameter is applied. In the case of Fig. 47(A), both lenses are designed to have the smallest aberration for equal substrate thickness.

[0352] Fig.47(B) shows the relation between optical information recording media with different substrate thicknesses and different recording densities and objective lenses. The reference character 437 denotes an optical information recording medium with a substrate thickness t1 and a high density. In this case, the objective lens 403 with a larger aperture diameter is applied, which is designed so that the aberration becomes the smallest for the substrate thickness t1. The reference character 438 denotes a conventional optical information recording medium with a substrate thickness t2. In this case, the objective lens 404 with a smaller aperture diameter is applied, and which is similarly designed so that the aberration becomes the smallest for the substrate thickness t2. As described above, providing objective lenses which satisfy optical characteristics required for applied optical information recording media and switching the lenses enable recording and regeneration to/from different kinds of optical information recording media. Although the focal lengths of the two objective lenses 403 and 404 are assumed to be equal in the description above, it is needless to say that the focal lengths can differ.

[0353] Fig.48 is a diagram showing a regeneration signal obtained when different optical information recording media are regenerated with objective lenses switched, and Fig.48(A) shows regeneration with the objective lens 403 and Fig.48(B) shows regeneration with the objective lens 404. Here, the light intensity of the laser beam emitted from the semiconductor laser is assumed to be constant. As has been described in Fig. 21, as the two objective lenses 403 and 404 have different aperture diameters, the light amount applied to the optical information recording medium is larger with the objective lens 403 with the larger aperture diameter and the applied light amount is smaller with the objective lens 404. Accordingly, it is a matter of course that the amplitude of the regenerated signal with the objective lens 403 is larger. In order to achieve stable recording and regenerating independently of differences of optical information recording media, the difference in applied amount of the laser beam caused by the difference of aperture diameter of objective lenses must be corrected.

[0354] Fig.49 is a current-optical output characteristic diagram of the semiconductor laser 411. Laser oscillation is performed at the threshold current I th or above, and the optical output can be increased by increasing the drive current. Hence, by switching the driving current of the semiconductor laser 411 at the same time as the objective lens is switched, the light amount applied onto the optical information recording medium 420 surface can be constant. Even if the objective lens 403 and the objective lens 404 have different aperture diameters, as the ratios of transmission through the respective lenses are previously known, the amount of switching the light amount can be set. For example, if the objective lens 403 requires the optical output of P1 and the optical output required for the objective lens 404 obtained from the transmittance ratio of the objective lens 403 and the objective lens 404 is P2, then the driving current of the semiconductor laser 411 is switched from I1 to I2.

[0355] The optical output of the semiconductor laser 411 may be changed so that the light amount applied to the optical information recording medium 420 is constant, or it may be controlled so that the regenerated signal amplitude is constant.

[0356] Fig.50 is circuit diagram showing the structure of the semiconductor laser 411. Generally, the package of the semiconductor laser 411 includes a laser chip 439 which makes laser oscillation and a photodetector 440. A part of the laser beam emitted from the laser chip 439 impinges upon the photodetector 440, which outputs a signal in proportion to the optical output of the laser chip 439. Accordingly, the optical output of the laser chip 439 can be grasped with this output signal and optical output can be set accurately on the basis of this signal also at the time of switch of the optical output. The setting and switching of the optical output value of the semiconductor laser 411 described above are achieved by distinguishing the kind of the optical information recording medium with the disk distinguishing circuit 427 when the optical information recording medium 420 is set, transferring instructions of the most suitable driving conditions to the laser driving circuit 430 from the control device 429, and operating the laser driving circuit 430 on

the basis of the instructions.

[0357] By the way, it is known that the semiconductor laser 411 has a characteristic that the laser oscillation becomes unstable when the laser beam externally emitted by the semiconductor laser 411 comes back to itself. In an optical information recording/regenerating device, reflected light from the optical information recording medium 420 or reflected light from optical parts constituting the optical system make the laser oscillation unstable, which appears as noise in the regenerated signal. The high frequency superposition method is known as a method for suppressing such noise. The reference character 432 denotes a high frequency superposition circuit for applying high frequency current to the semiconductor laser to suppress the noise, and 431 denotes a power supply circuit for driving the high frequency superposition circuit 432.

[0358] Fig.51 is a circuit diagram showing the structure of the high frequency superposition circuit 432. In the figure, 441 denotes an oscillating stage, and 442 denotes an amplifying stage for amplifying the high frequency signal oscillated at the oscillating stage 441. The oscillating stage 441 and the amplifying stage 442 can be independently supplied with power from the power supply circuit 431, for example. Here, the oscillating stage 441 is supplied with a fixed voltage V1 and the amplifying stage 442 is supplied with a variable voltage V2, where varying the voltage V2 changes the amplification degree so as to vary the magnitude of the high frequency current applied to the semiconductor laser 411.

[0359] Fig.52 is a current-optical output characteristic diagram of the semiconductor laser in accordance with absence/present of high frequency superposition. 443 denotes a characteristic line when high frequency superposition is not performed, which is the same as the characteristic shown in Fig.49. 444 denotes characteristic lines when high frequency superposition is performed, where the characteristic line shifts to the left as 444a, 444b, 444c as the amount of applied high frequency current increases. Then, if the optical output is P1, then the shift amount of the characteristic line corresponds to the applied amount of the high frequency current. The applied amount of the high frequency current required to suppress noise, though it differs according to various conditions such as kind of the semiconductor laser, the magnitude of return light etc., is generally sufficient if the shift amount of the characteristic line with the optical output P1 is several mA. Accordingly, the high frequency current is to be applied with the voltage V2 of the amplifying stage 442 set so that the current value I1' when the high frequency superposition is performed is smaller by several mA than the current value I1 when high frequency superposition is not performed.

[0360] Next, when it is switched to the objective lens 404, the optical output of the semiconductor laser 411 is also switched from P1 to P2 at the same time. If the amount of applied high frequency current is unchanged, however, the characteristic line is not shifted at the optical output P2 as shown in Fig.52, and then noise can not be suppressed sufficiently.

[0361] Fig.53 is a current-optical output characteristic diagram of the semiconductor laser when the high frequency superposition is made larger. By adjusting the voltage V2 of the amplifying stage 442, at the optical output P2, it can be set so that the shift amount of the characteristic line 445 when high frequency superposition is performed with respect to the characteristic line 443 when high frequency superposition is not applied is the same as that at the optical output P1. Accordingly, by switching the high frequency superposition simultaneously with switch of the optical output, noise can be suppressed stably. Switch of voltage of the amplifying stage 442 of the high frequency superposition circuit 432 is achieved by the disk distinguishing circuit 427 distinguishing the kind of the optical information recording medium when the optical information recording medium 420 is set, the control device 429 transferring instructions of the most suitable driving conditions to the power supply circuit 431, and the power supply circuit 431 supplying a predetermined voltage to the amplifying stage 442 on the basis of the instructions.

<23. Twenty-third Preferred Embodiment>

<23-1. Device Structure>

[0362] Fig.54 is a diagram showing the structure of an optical system and an electric system of an optical information recording/regenerating device 400A in a twenty-third preferred embodiment of the present invention, where the same characters are allotted to the same structures as those in the optical information recording/regenerating device 400 of Fig.45 and overlapping description is not repeated here. In this twenty-third preferred embodiment, the control signal outputted from the control device 429 is connected to the focusing error detecting circuit 424, the tracking error detecting circuit 425 and the regeneration signal detecting circuit 426, respectively.

[0363] In the twenty-second preferred embodiment, when objective lenses are switched for different kinds of optical information recording media, optical output of the semiconductor laser 411 is also switched at the same time to control so that the signal amplitude is constant. However, the amplification degree of the detected signal may be varied with the optical output of the semiconductor laser 411 being constant to control so that the signal amplitude is constant. In the twenty-third preferred embodiment, when the optical information recording medium 420 is installed, the disk distinguishing means 427 distinguishes a kind of the optical information recording medium, the control device 429 transfers instructions for the most suitable amplification degree to the focusing error detecting circuit 424, the tracking error detecting circuit 425 and the regeneration signal de-

tecting circuit 426, respectively, and signals are outputted from the respective circuits on the basis of the amplification degree. Hence, according to the twenty-third preferred embodiment, signals with stable quality can be obtained even with different kinds of optical information recording media.

<24. Twenty-fourth Preferred Embodiment>

<24-1. Device Structure>

[0364] Fig.55 is a block diagram of a current-voltage converting circuit in a twenty-fourth preferred embodiment of the present invention, where the same characters are allotted to the same structures as those in Fig. 45 and overlapping description in not made here. In this preferred embodiment, the current-voltage converting circuit 46 connected to the photodetector 422 is formed of four current-voltage converting circuits 446a-446d with variable load resistances. Although a description is made here with four current-voltage converting circuits, it is a matter of course that the number of current-voltage converting circuits depends on the number of light receiving surfaces of the photodetector. Signal from the control device 429 is connected to the current-voltage converting circuits 446a-446d, respectively.

<24-2. Device Operation>

[0365] In the twenty-third preferred embodiment, the amplification degrees of the focusing error detecting circuit 424, the tracking error detecting circuit 425 and the regeneration signal detecting circuit 426 are switched when the objective lenses are switched for different kinds of optical information recording media, but load resistance values of the current-voltage converting circuits 446a-446d are switched in the twenty-fourth preferred embodiment, where when the optical information recording medium is installed, the disk distinguishing circuit 427 distinguishes a kind of the optical information recording medium, the control device 429 transfers instructions for the most suitable load resistance values to the current-voltage converting circuits 446a-446d, and respective circuits output signals on the basis of the load resistance values. Hence, according to the twenty-fourth preferred embodiment, signals with stable quality are obtained with different kinds of optical information recording media.

<25. Twenty-fifth Preferred Embodiment>

[0366] While the optical output is changed or a change is made in the electric circuit system when an objective lens is changed for an optical information recording medium of a different kind so that the amplitude of the detected signal becomes constant, for example, in the twenty-second to twenty-fourth preferred embodiments described above, it is changed so that the sensitivity of the detected signal becomes constant in the twenty-fifth preferred embodiment.

[0367] Fig.56 is a tracking error signal diagram obtained when optical information recording media of different kinds are regenerated in the twenty-fifth preferred embodiment, where Fig.56(A) is a tracking error signal diagram obtained when a first optical information recording medium is regenerated and Fig.56(B) is a tracking error signal diagram when a second optical information recording medium with a track pitch larger than that of the first optical information recording medium is regenerated with the amplitude being the same as that of the first optical information recording medium. In Fig.56 (B), though the amplitude is the same as that of the first optical information recording medium, the inclination of the signal, i.e., the sensitivity line 447 is not the same as the sensitivity line 448 of the first optical information recording medium since the track pitch is larger.

[0368] In Fig.56(C), the optical output or the electric circuit system is switched so that the sensitivity line 449 of the signal of the second optical information recording medium becomes equal to the sensitivity line 448 of the first optical information recording medium, where the amplitude is larger than that in Fig.56(A). As the sensitivity, rather than the amplitude, affects the control accuracy in follow-up of tracking, switching can be made so that the sensitivity is constant to keep the control accuracy constant. This is the same as to the focusing error signal.

<26. Twenty-sixth Preferred Embodiment>

<26-1. Device Structure>

[0369] Fig.57 is a block diagram showing the structure of a high frequency superposition circuit in a twenty-sixth preferred embodiment of the present invention. In the figure, 450 denotes a high frequency superposition circuit, 451 denotes a power supply circuit for supplying a constant power-supply voltage to the high frequency superposition circuit 450, 452 denotes an oscillating stage, and 453 denotes an amplifying stage, where the control signal from the control device 429 is inputted to the amplifying stage 453, and which amplifying stage 453 is constructed so that the amplification degree can be changed on the basis of external control signal.

<26-2. Device Operation>

[0370] In this twenty-sixth preferred embodiment, when the optical information recording medium 420 is installed, the disk distinguishing circuit 427 distinguishes a kind of the optical information recording medium, the control device 429 transfers instructions for the most suitable amplification degree to the amplifying stage 453, and high frequency current is applied to the semiconductor laser 411 from the high frequency superposition circuit 450 on the basis of the amplification degree.

Thus, the high frequency superposition is switched at the same time as the switch of the optical output, providing stable suppression of noise.

<27. Twenty-seventh Preferred Embodiment>

[0371] While switch of the optical output of the semiconductor laser 411, or switch of the amplification degree or the load resistance of the electric circuit system, is independently made simultaneously with switch of an objective lens for an optical information recording medium of a different kind in the twenty-second through twenty-sixth preferred embodiments described above, they may be achieved in combination at the same time, or switch of amplification degree or load resistance may be achieved differently for each circuit.

[0372] Fig.58 shows the structure of an optical system and an electric system of an optical information recording/regenerating device 400B. The same reference characters are allotted to the same structures as those in the optical information recording/regenerating device 400 described referring to Fig.45 and the optical information recording/regenerating device 400A described referring to Fig.54, and overlapping description is not repeated here.

[0373] While the amounts of switching the optical output or in the electric circuit system with switching of the objective lens for a different optical information recording medium are previously set with the kind of the optical information recording medium and the aperture diameter of the objective lens in the twenty-second through twenty-sixth preferred embodiments, a signal may be actually detected to make correction as needed for the most suitable signal amplitude or signal sensitivity on the basis of the signal characteristics. This enables to be absorbed influences on the signal characteristics caused by fine variation of reflectance of surfaces of optical information recording media, even of optical information recording media of the same kinds.

[0374] Although the twenty-second through twenty-sixth preferred embodiments have shown examples in which two objective lenses are switched to each other, it is needless to say that three or more objective lenses may be switched to each other in the same way with switch of the optical output or in the electric circuit system.

<28. Twenty-eighth Preferred Embodiment>

<28-1. Device Structure>

[0375] Fig.59 is a diagram showing the structure of an optical system and an electric circuit of an optical information recording/regenerating device 500 in a twenty-eighth preferred embodiment of the present invention. The same characters are allotted to the same structures as those in the optical information recording/regenerating device 400 according to the present invention described referring to Fig.45, and overlapping description is not repeated here.

[0376] In Fig.59, a diffraction grating 510 is provided between a collimator lens 411 and a beam splitter 413 and an objective lens driving device 515 is provided in the direction of reflection of the mirror 108. The lens holder 6 of the objective lens deriving device 515 is equipped with objective lenses 503 and 504.

[0377] A lens 421 and a photodetector 522 are provided in order in the direction of reflection of the beam splitter 413 seen from the optical information recording medium 420.

[0378] Here, as the objective lens driving device 515, the objective lens driving device 400 shown in Fig.1 is used, for example. Accordingly, though overlapping description is not repeated here, the objective lenses 3 and 4 in Fig.1 serve as the objective lenses 503 and 504 and the tracking magnets 107a and 107b and the tracking coils 121a and 121b are generically referred to as the driving mechanism 419.

<28-2. Device Operation>

[0379] The same operations as those of the optical information recording/regenerating device 400 are not described here. Next, referring to Fig.60, the relation between the optical characteristics of the objective lenses and condensed light spots will be described. Fig.60 shows an important part of the optical system for applying laser beam to the optical information recording medium 420, which particularly shows the diffraction grating 510, the objective lens 503 and the objective lens 504. Fig.60(a) shows the case of the objective lens 503 and Fig.60(b) shows the case of the objective lens 504. The reference character 533 is a diaphragm provided on the incident side of the objective lens 503, which is a circular aperture with radius r1, for example. Similarly, 534 is a diaphragm provided on the incident side of the objective lens 504, which is a circular aperture with radius r2. The focal lengths of the objective lenses 503 and the objective lens 504 are f1 and f2, respectively, and it is assumed here that $f1<f2$. The reference character 535 denotes a laser beam coming out of the collimator lens 412. The laser beam 535 enters the diffraction grating 510 to be divided into the zero-order beam 537 not subject to the diffracting effect, the positive first-order beam 538 which is diffracted by $+\theta$ with respect to the optical axis 536, and the negative first-order beam 539 which is diffracted by $-\theta$ with respect to the optical axis 536.

[0380] In Fig.60(a), the laser beam 537 parallel to the optical axis 536 is subject to the condensing effect of the objective lens 503 and forms a condensed light spot 537a on the optical axis 536. The laser beams 538 and 539 inclined by θ with respect to the optical axis 536 respectively form the condensed light spots 538a and 539a at positions displaced by e1 from the optical axis 536 due to the light condensing effect of the objective

lens 503. This amount of displacement e1 is given by f1 · θ using the focal length f1 of the objective lens 503. (· indicates multiplication) Similarly, in Fig.60(b), the laser beam 535 forms the condensed light spot 537b on the optical axis 536.

[0381] The laser beams 538 and 539 inclined by θ with respect to the optical axis 536 respectively form condensed light spots 538b and 539b at positions displaced by e2 from the optical axis 536 by the light condensing effect of the objective lens 504. The displacement amount 2e is given by f2 · θ using the focal length f2 of the objective lens 504. As the relation f1<f2 about the focal length exists as mentioned above, the relation e1<e2 holds about the displacement amount from the optical axis 536. These displacement amounts correspond to the intervals of the condensed light spots. The effective aperture diameter of the objective lens 503 is defined by the diaphragm 533 with the circular aperture with the radius rl, and the numerical aperture NA1 of the objective lens 503 defined by the aperture radius for the focal length is r1/f1. Similarly, the effective aperture diameter of the objective lens 504 is defined by the diaphragm 534 of the circular aperture with the radius r2, and the numerical aperture NA2 of the objective lens 504 is r2/f2. Generally, as a numerical aperture of a lens is larger, a smaller spot diameter can be formed. In Fig. 60, if r1 and r2 are similar, then NA1>NA2 from the relation of f1<f2. Accordingly, the objective lens 503 can form a smaller condensed light spot than the objective lens 504, thus obtaining a smaller spot interval.

[0382] Next, the method of detecting the tracking error will be specifically described using Fig.61 and Fig.62. Fig.61 is a plan view showing the relation between the optical information recording medium and condensed light spots. Fig.61(a) shows the case where the objective lens 503 is selected and information is regenerated with a high density optical information recording medium with small track pitch p1. Fig.61(b) shows the case where the objective lens 504 is selected and information is regenerated with an optical information recording medium having track pitch p2 larger than p1. In Fig.61(a), the condensed light spot line 540 connecting the three condensed light spots 537a-539a is only slightly inclined with respect to the line of the information pits 541, and the condensed light spot 537a with the zero-order beam 537 is disposed at the center of the information pits 541 to regenerate information. The two condensed light spots 538a and 539a with the diffracted laser beams are displaced in opposite directions with respect to the center condensed light spot 537a, and the displacement amount s1 thereof is about one fourth of the track pitch p1.

[0383] Fig.62 is a plan view representing the shape of the light receiving surface of the photodetector 522 and a tracking error signal detecting circuit connection diagram. In the figure, 522a is a light receiving surface arranged to receive the reflected light of the condensed light spot 537a at the center, which is formed of a light receiving surface which is equally divided into four, for example. This is for the purpose of being adaptable to focusing error detection by the known astigmatism method, which is not described herein. The light receiving surfaces 522b and 522c are light receiving surfaces arranged on the opposite sides with the light receiving surface 522a interposed therebetween, which receive the reflected lights of the condensed light spots 538a and 539a, respectively. The output signals of the light receiving surfaces 522b and 522c are connected to differential input terminals of the differential amplifier 542.

[0384] Fig.61(a) and Fig.62 show the structure of a tracking error signal detecting method (differential push-pull method) by the known three-beam method, where the output signal TE of the differential amplifier 542 becomes a tracking error signal. In the three-beam method, it forms suitable conditions that the condensed light spots 538a and 539a on both ends are displaced from the information pit 541 line to each other by one fourth of the track pitch.

[0385] Next, when an optical information recording medium of a different kind with a track pitch larger than p1 undergoes regeneration, the objective lens 504 is selected and the condensed light spots are arranged as shown in Fig.61(b). Here, if the tracking error detection by the three-beam method is made under the suitable conditions in the same way as shown in Fig.61(a), the condensed light spots 538b and 539b on both ends must be displaced by about one fourth of the track pitch p2 in the opposite direction to each other with respect to the condensed light spot 537b in the center. Here, as the inclination of the condensed light spot line 540 is the same with respect to the direction in which the information pits 541 are arranged, the suitable conditions can be satisfied if the condensed light spot interval e2 is larger then e1 by the track pitch ratio p2/p1.

[0386] Since the condensed light spot interval is in proportion to the focal length of the objective lens as mentioned above, the tracking error detection by the three-beam method can be achieved under the suitable conditions by setting the focal length of the objective lens to be almost proportional to the track pitch. When the objective lens 504 is selected, the tracking error detection is made by the three-beam method with the reflected lights of the condensed light spots 538b and 539b on both ends being incident upon the light receiving surfaces 522b and 522c, respectively. Hence, it is clear from the description above that a single diffraction grating 510 for forming three beams and an optical system for tracking error detection are sufficient even in an optical information recording/regenerating device having a plurality of objective lenses.

[0387] Recording or regenerating with a small condensed light spot is essential for a high density optical information recording medium with the small track pitch p1. As the focal length f1 of the objective lens 503 is small in correspondence to the track pitch p1, its numerical aperture is apt to be large. Accordingly, the con-

densed light spot formed by the objective lens 503 is smaller than that by the objective lens 504, and setting the focal length of the objective lens to be almost proportional to the track pitch forms suitable conditions also from the point of view of the condensed light spot.

[0388] Fig.63 is a side view showing the relation between the optical information recording media species and objective lenses, where Fig.63(A) shows the relation between optical information recording media with the same substrate thickness and different recording densities and objective lenses. The reference character 543 is a high density optical information recording medium, to which the objective lens 503 with a small focal length is applied. The reference character 544 denotes a conventional optical information recording medium, to which the objective lens 504 with a large focal length is applied. In the case of Fig.63(A), the two lenses are designed so that the aberration becomes the smallest for the same substrate thickness.

[0389] Fig.63(B) shows the relation between optical information recording media with different substrate thicknesses and recording densities and objective lenses. The reference character 545 denotes a high density optical information recording medium with a substrate thickness t1. In this case, the objective lens 503 with a small focal length is applied, the objective lens 503 being designed so that the aberration becomes the smallest for the substrate thickness t1. The reference character 546 shows a conventional optical information recording medium with a substrate thickness t2. In this case, the objective lens 504 with a larger focal length is applied, the objective lens 504 being designed so that the aberration becomes the smallest for the substrate thickness t2. As described above, by providing objective lenses which satisfy optical characteristics required for applied optical information recording media and switching the lenses, recording and regenerating can be made with optical information recording media of different kinds.

<29. Twenty-ninth Preferred Embodiment>

<29-1. Device Structure>

[0390] Fig.64 is a sectional view showing an objective lens of an optical information recording/regenerating device in a twenty-ninth preferred embodiment of the present invention. The reference character 548 denotes an objective lens, which includes an integrally formed lens portion 548a and mirror frame portion 548b (the shadowed part).

<29-2. Device Operation>

[0391] The mirror frame portion 548b has a function as a diaphragm for limiting the aperture of the lens portion 548a, so that it is not necessary to provide the diaphragm 533 or 534 shown in Fig.34 when the objective lens 548 is of a predetermined numerical aperture.

[0392] It is a matter of course that an objective lens with a diaphragm and an objective lens having no diaphragm may be mixed in a plurality of objective lenses in a single optical information recording/regenerating device.

<30. Thirties Preferred Embodiment>

<30-1. Device Structure>

[0393] Next, a thirtieth preferred embodiment of the present invention will be described referring to Fig.65 and Fig.66. Fig.65 is a plan view showing the relation between an optical information recording medium and condensed light spots. Fig.65(a) shows recording or regeneration of information with a high density optical information recording medium having small track pitch p3 with the objective lens 503 being selected. Fig.65(b) shows recording and regeneration of information with an optical information recording medium having larger track pitch p4 than p3 with the objective lens 504 being selected.

<30-2. Device Operation>

[0394] In Fig.65(a), the condensed light spot line 549 connecting the three condensed light spots 537a-539a is slightly inclined with respect to the guide groove 550, and the condensed light spot 537a by the zero-order beam 37 is disposed at the center of the guide groove 550 to record or regenerate signals. The two condensed light spots 538a and 539a by diffracted laser beams are displaced in opposite directions to each other with respect to the condensed light spot 537a at the center, and the displacement amount s3 is about a half of the track pitch p3.

[0395] Fig.66 is a plan view showing the configuration of the light receiving surface of the photodetector 551 corresponding to the photodetector 522 of Fig.62 and a tracking error signal detecting circuit connection diagram. The reference character 551a denotes a light receiving surface divided into two in the direction along the guide groove, for example, which is arranged to receive the reflected light of the condensed light spot 537a at the center around the dividing line of the light receiving surface. The light receiving surfaces 551b and 551c are arranged on opposite sides with the light receiving surface 551a interposed therebetween, which are also divided into two in the direction along the guide groove and arranged to receive the reflected lights of the condensed light spots 538a and 538a around the dividing lines of the light receiving surfaces, respectively. The output signals of the two-divided light receiving surfaces 551a-551c are respectively inputted to differential input terminals of the differential amplifiers 552-554. The output signals from the light receiving surfaces on the same side with respect to the dividing line of the respectively

two-divided light receiving surfaces 551a-551c are inputted to the same polarity side of the differential amplifiers 552-554. The output signal of the differential amplifier 554 is connected to the variable amplifier 555. The output signal of the differential amplifier 553 and the output signal of the variable amplifier 555 are synthesized and connected to the variable amplifier 556. The output signal from the variable amplifier 556 is connected to the differential input terminal of the differential amplifier 557.

[0396] The method of detecting the tracking error described above is called a differential push-pull method, and the principle of the signal detection is shown in Japanese Patent Laying-Open No.61-94246, so its description is not further made herein. The output signal TE of the differential amplifier 557 becomes a tracking error signal. In the differential push-pull method, it forms suitable conditions that the condensed light spots 538a and 539a on both ends are displaced with each other from the guide groove 550 by a half with respect to the track pitch.

[0397] Next, when information is recorded or regenerated with an optical information recording medium of a different kind with a guide groove larger than p1, the objective lens 504 is selected and condensed light spots are arranged as shown in Fig.65(b). Here, if the tracking error detection by the differential push-pull method is to be made under the suitable conditions the same as Fig. 65(a), the condensed light spots 538b and 539b on both ends must be displaced by about a half of the track pitch p2 in the opposite directions to each other with respect to the condensed light spot 537b at the center. Now, as the inclination of the condensed light spot line 549 with respect to the direction of the guide groove 550 is the same, the suitable conditions can be satisfied if the condensed light spot interval e2 is larger than e1 by the track pitch ratio p2/p1. Similarly to the twenty-eighth preferred embodiment, since the condensed light spot interval is in proportion to the focal length of the objective lens as described above, the tracking error detection by the differential push-pull method can be made under suitable conditions by setting the focal length of the objective lens to be almost proportional to the track pitch.

[0398] When the objective lens 504 is selected, the tracking error detection by the differential push-pull method is made with the reflected light of the condensed light spot 537b at the center being incident upon the light receiving surface 551a and the reflected lights of the condensed light spots 538b and 539b on both ends being respectively incident upon the light receiving surfaces 551b and 551c.

[0399] Similarly to the twenty-eighth preferred embodiment, it forms suitable conditions to set the focal length of the objective lens to be almost in proportion to the track pitch also from the point of view of the size of the condensed light spot given by the numerical aperture.

[0400] Although the above description has shown cases of switching two objective lenses, it is a matter of course that three or more objective lenses may be provided.

Claims

1. An optical information recording/reproducing device, comprising:

    an objective lens driving device including a lens holder (6) held turnable around and movable along an axis line; a plurality of objective lenses (3, 4) provided on said lens holder, driving means for driving a light spot on an optical information recording medium in a focus direction and a direction across a track by moving and turning said lens holder along and around said axis line;
    said optical information recording/reproducing device further comprising
    a light source (341);
    an optical element (342) for dividing a light beam emitted from said light source (341) into a plurality of divided light beams at a predetermined ratio;
    a light receiving element (348) for receiving the light reflected from the recording medium; and
    means for outputting a distinguishment signal corresponding to the kind of said optical information recording medium, wherein
    said objective lens driving device selects one of said plurality of objective lenses corresponding to the kind of recording medium according to said distinguishment signal and moves the selected lens into the light from the source to form a light spot.

2. The optical information recording/reproducing device of claim 1, further comprising:

    a current voltage converting circuit (390);
    a focusing error generating circuit (392);
    a tracking error generating circuit (393);
    a reproduction signal detecting circuit (394);
    a circuit (395) for generating a pulse current when the selected objective lens (3, 4) is not disposed in the optical path; and
    a driving device driving circuit (396) for driving said objective lens driving device.

3. The optical information recording/reproducing device of claim 2 wherein the light source (341) is a laser light source; the device comprising

    means (430) for switching the light intensity of a laser beam emitted from said laser light source (341) corresponding to said selected objective lens (3, 4).

4. The optical information recording/reproducing device of claim 3, further comprising

high frequency current driving means for providing high frequency current for said laser light source, wherein
high frequency current is applied to said laser light source in addition to a driving current for emitting a laser beam, and
said high frequency current is switched in value corresponding to switching of said objective lenses.

5. The optical information recording/reproducing device of claim 4, wherein
the value of said high frequency current can be varied by varying the value of a source voltage of said high frequency current driving means.

6. The optical information recording/reproducing device of claim 4, wherein
the value of said high frequency current can be varied by varying the amplification degree of said high frequency current driving means.

7. The optical information recording/reproducing device of claim 2, further comprising:

signal detecting means for detecting an information signal and an error signal from an output of said photodetector; and
means for switching an amplification degree of said signal detecting means corresponding to said selected objective lens, wherein
said signal detecting means includes a first electric circuit system for detecting said information signal and said error signal.

8. The optical information recording/reproducing device of claim 2, wherein
said light source is a laser light source (411);
said device further comprising:

means (431) for switching the light intensity of a laser beam emitted from said laser light source corresponding to said selected objective lens;
signal detecting means for detecting an information signal and an error signal from an output of said photodetector; and
means for switching the amplification degree of said signal detecting means corresponding to said selected objective lens, wherein
said signal detecting means includes a first electric circuit system for detecting said information signal and said error signal, and
the light intensity of a laser beam emitted from said laser light source is switched to have a different value and the amplification degree of said first electric circuit system is switched to have a different value, corresponding to switching of said objective lenses.

9. The optical information recording/reproducing device of claim 7 or 8, wherein
the amplification degree of an electric circuit (424, 425, 426) for generating said information signal and said error signal is switched to have a different value in said first electric circuit system.

10. The optical information recording/reproducing device of claim 7 or 8, wherein
said first electric circuit system includes a second electric circuit system for converting an output current of said light receiving element (422) receiving said laser beam into a voltage, and said first system switches the load resistance of said second electric circuit system to have a different value.

11. The optical information recording/reproducing device of any one of claims 3, 7 and 8, wherein
said plurality of objective lenses individually have different numerical diameters.

12. The optical information recording/reproducing device of any one of claims 3, 7 and 8, wherein
said plurality of objective lenses individually have different numerical apertures.

13. The optical information recording/reproducing device of claim 3, wherein

said plurality of objective lenses individually have different numerical diameters, and
the light intensity of said laser beam is switched so as to correct the difference in transmittance due to different numerical diameters of said plurality of objective lenses.

14. The optical information recording/reproducing device of claim 7 or 8, wherein

said plurality of objective lenses individually have different numerical diameters, and
the light intensity of said laser beam and/or the amplification degree of said first electric circuit system is/are switched to have a different value so as to correct the difference in transmittance due to different numerical diameters of said plurality of objective lenses.

15. The optical information recording/reproducing device of claim 7 or 8, wherein
the light intensity of said laser beam and/or the amplification degree of said first electric circuit system is/are switched to have a different value so

as to correct the amplitude of said information signal and said error signal.

16. The optical information recording/reproducing device of claim 7 or 8, wherein
the light intensity of said laser beam and/or the amplification degree of said first electric circuit system is/are switched to have a different value to as to correct the sensitivity of said error signal.

17. The optical information recording/reproducing device of claim 7 or 8, wherein
the amplification degree of said first electric circuit system is corrected based on the intensity of laser beam reflected by said optical information recording medium.

18. The optical information recording/reproducing device of claim 2, wherein

the light source (341) is a laser light source,
the first optical element (342) divides a laser beam emitted from the laser light source into at least three laser beams,
the first optical element (342) leads the three laser beams to the selected objective lens (3. 4) to be condensed and applied upon the optical information recording medium as three condensed light spots and inclines said laser beam by a predetermined angle so that the pitch of information track of the optical information recording medium and the spot interval of the three condensed light spots formed by the selected objective lens are in proportion to each other.

19. The optical information recording/reproducing device of claim 18, wherein
said plurality of objective lenses have individually different focal lengths.

20. The optical information recording/reproducing device of claim 18, wherein
each of said plurality of objective lenses is provided to correspond to the difference in substrate thickness of said optical information recording medium.

21. The optical information recording/reproducing device of claim 18, wherein
focal length of said plurality of objective lenses is set in proportion to the pitch of information track of said optical information recording medium.

22. The optical information recording/reproducing device of claim 18, wherein
aperture diameter limiting means (533, 534) is provided separately from at least one of said plurality of objective lenses.

23. The optical information recording/reproducing device of claim 18, wherein
aperture diameter limiting means is provided integrally with at least one of said plurality of objective lenses.

24. The optical information recording/reproducing device of claim 18, wherein
one of said plurality of objective lenses with shorter focal length has a numerical aperture larger than that of another one of said plurality of objective lenses with longer focal length.

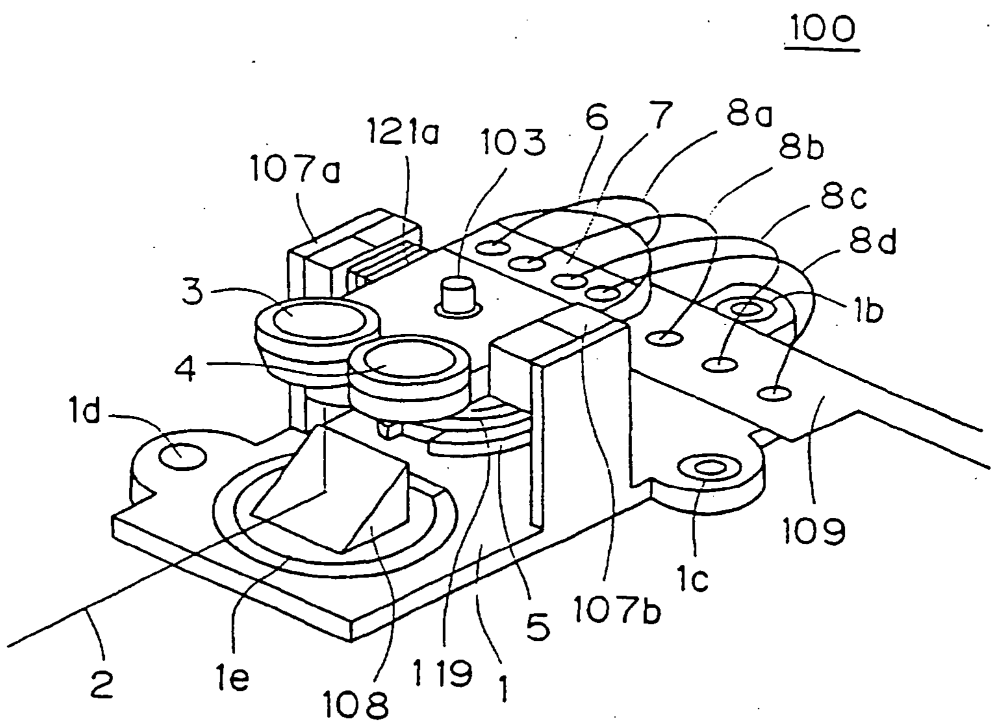
25. The optical information recording/reproducing device of claim 18, wherein
said first optical element is provided in common to said plurality of objective lenses.

26. The optical information recording/reproducing device of claim 18, further comprising
an optical system for detecting a tracking error signal. provided in common to said plurality of objective lenses.

27. The optical information recording/reproducing device of claim 18, further comprising
an optical system for detecting a tracking error signal, said system being in a three beam system.

28. The optical information recording/reproducing device of claim 18, further comprising
an optical system for detecting a tracking error signal, said system being in a differential push-pull system.

F I G . 1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7
8a
8b
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1e
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1
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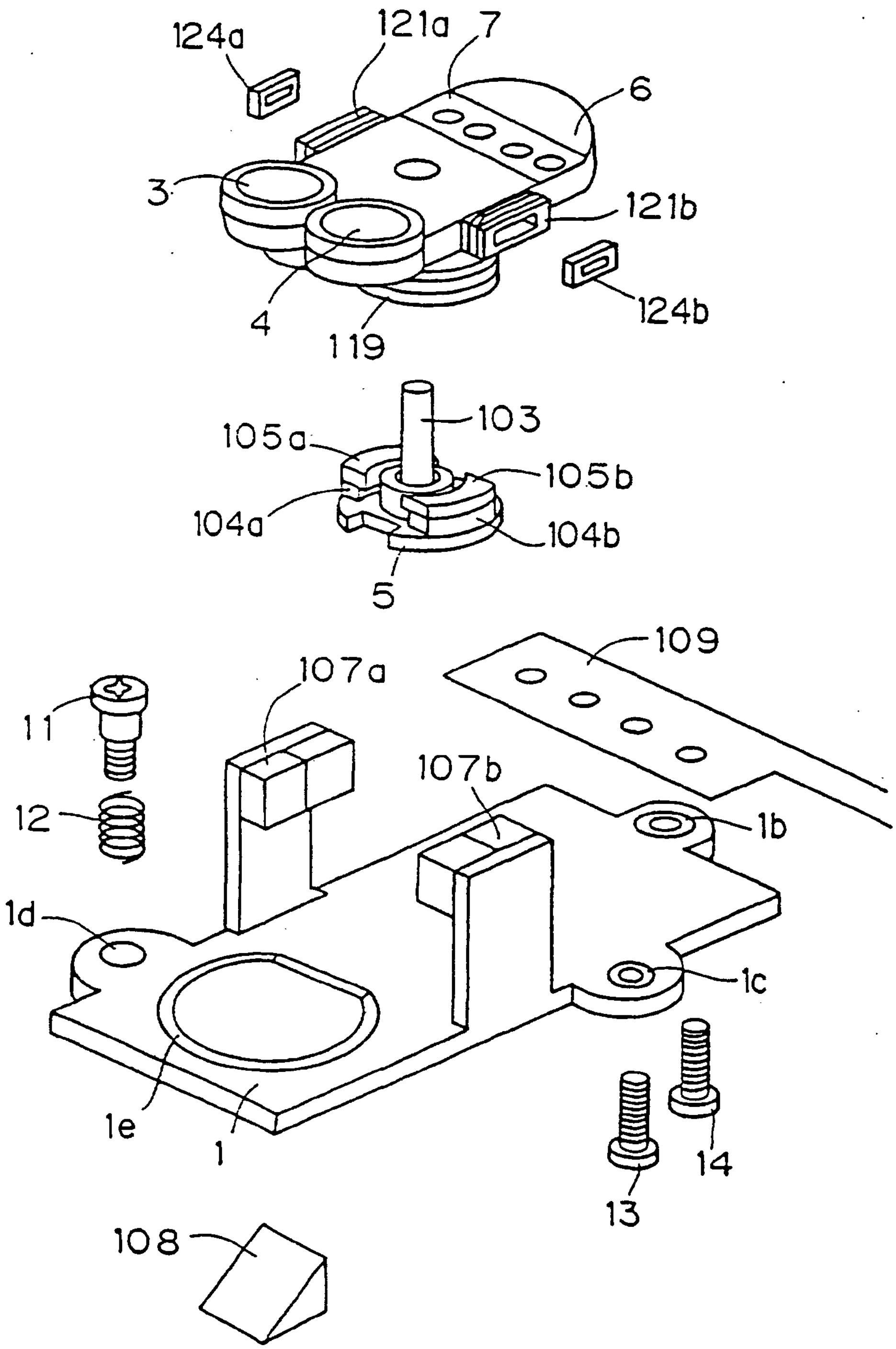
FIG. 2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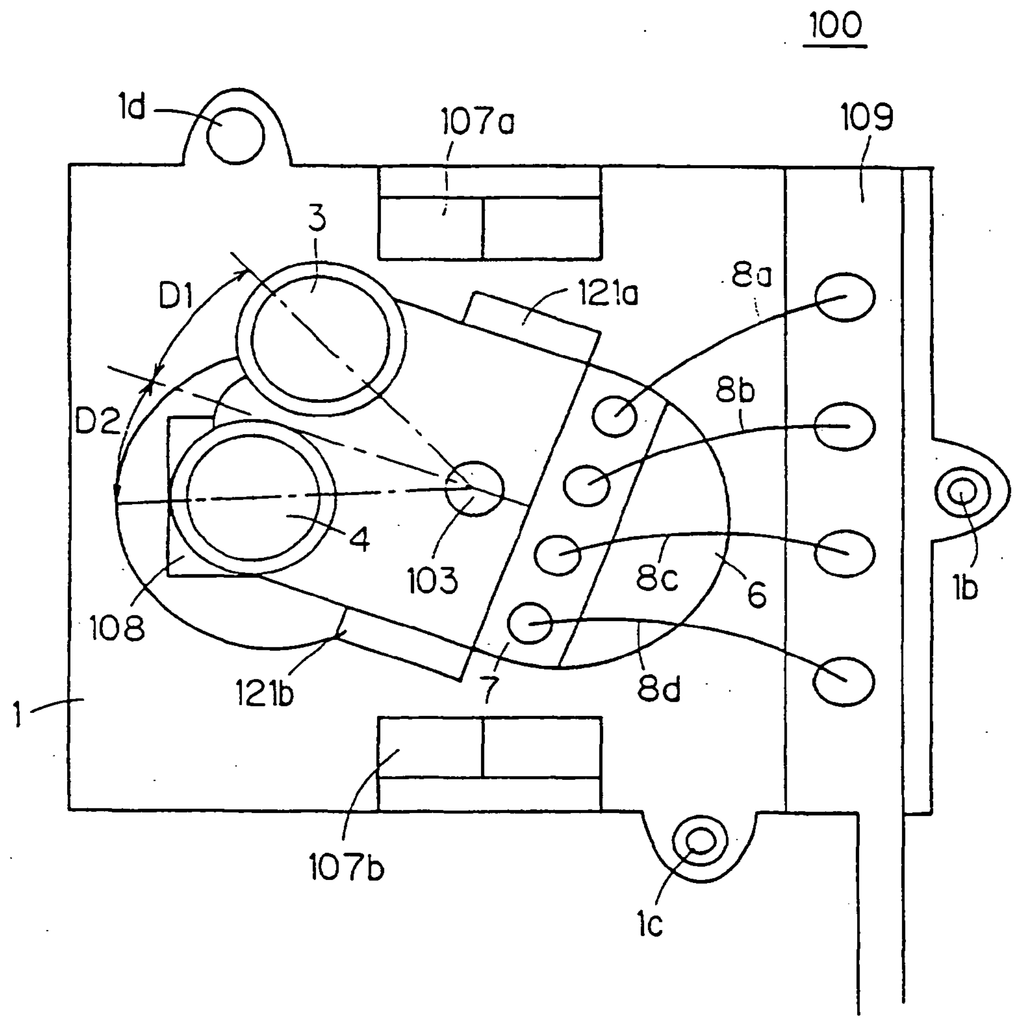
1c
1e
1
14
13
108

FIG. 3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109
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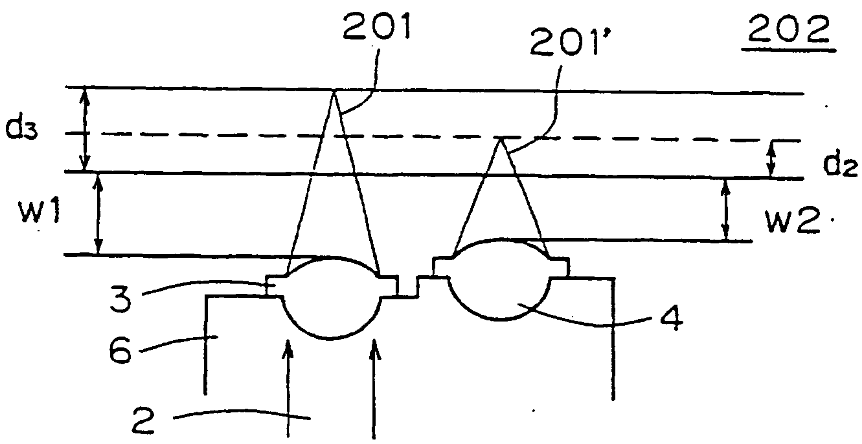
107b
1c

FIG. 4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201'
202
d3
d2
w1
w2
3
4
6
2

FIG. 5

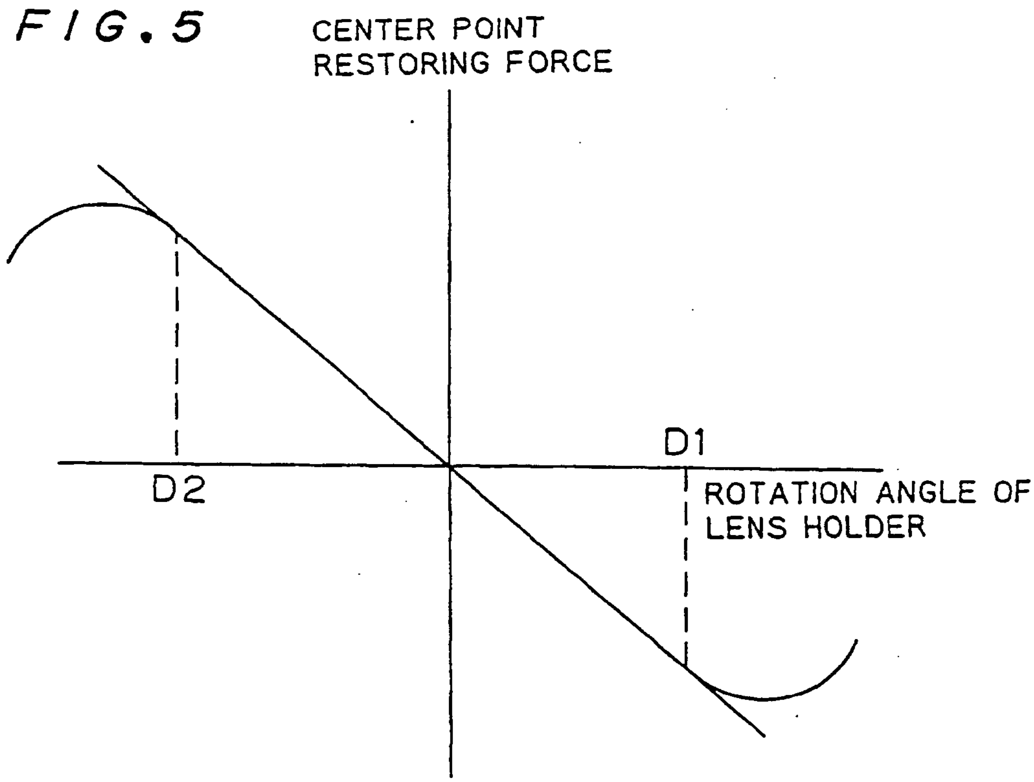
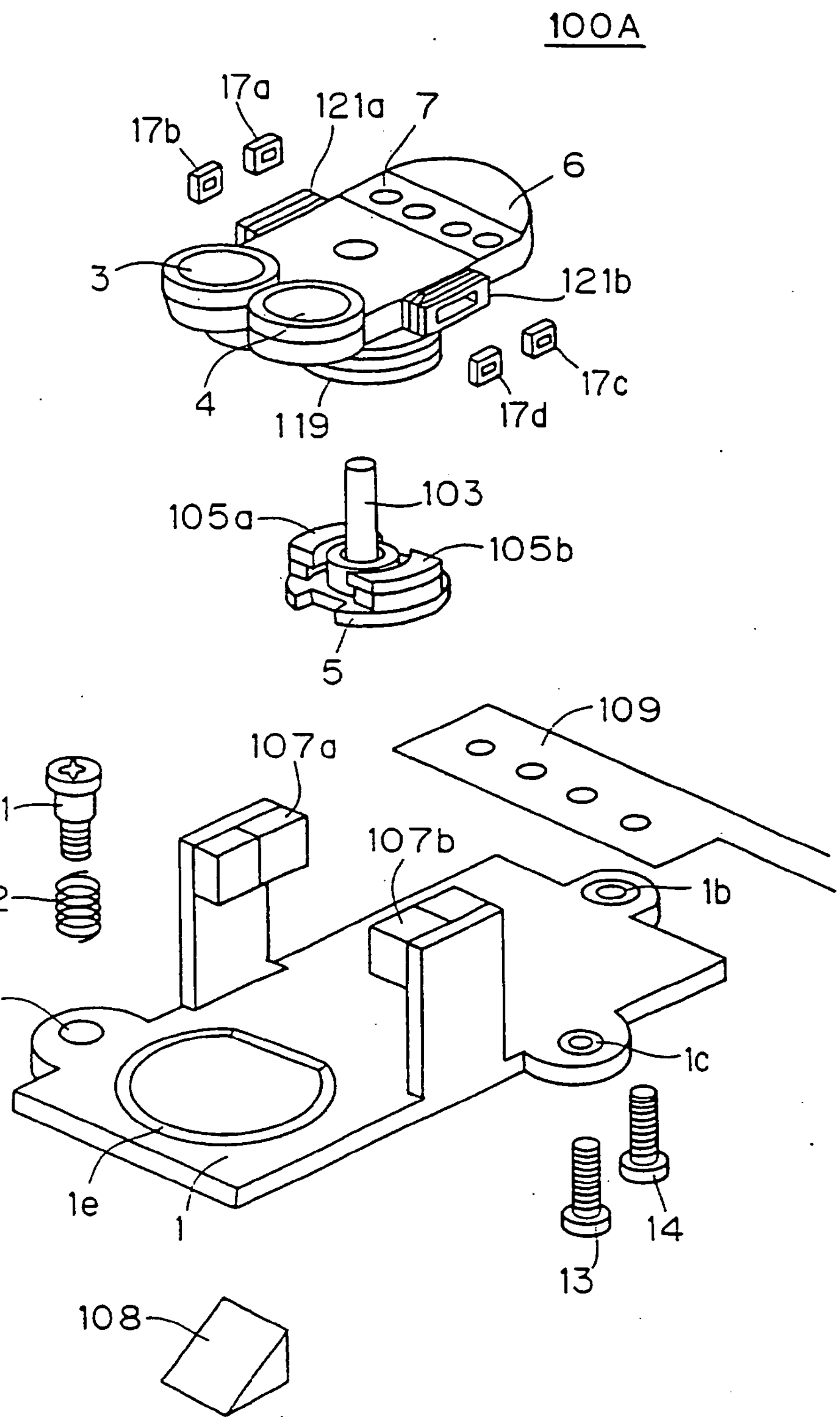

CENTER POINT
RESTORING FORCE
D1
D2
ROTATION ANGLE OF
LENS HOLDER

FIG. 6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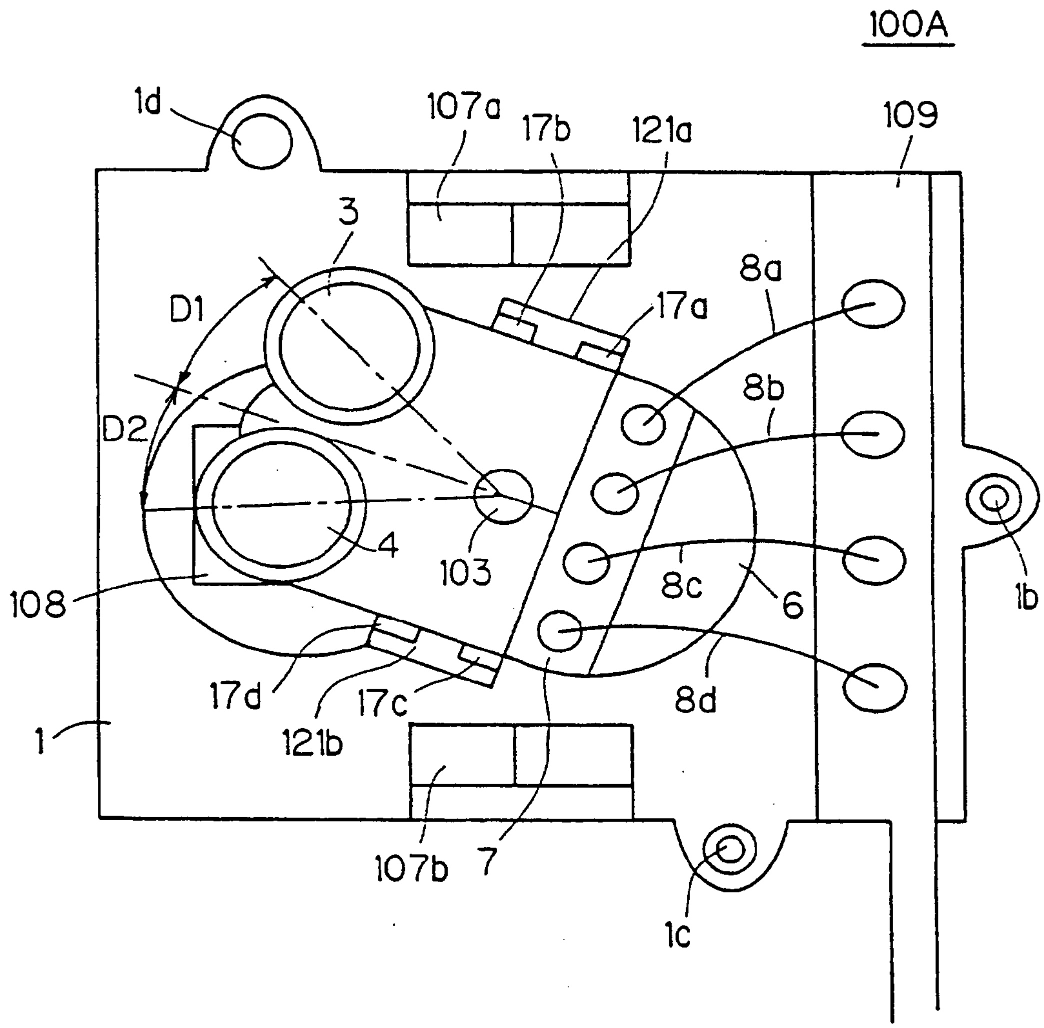
17b
121a
7
6
3
121b
17c
17d
4
119
103
105a
105b
5
109
107a
11
107b
12
1b
1d
1c
1e
1
14
13
108

FIG. 7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17a
D1
8b
D2
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107b
7
1c

FIG. 8

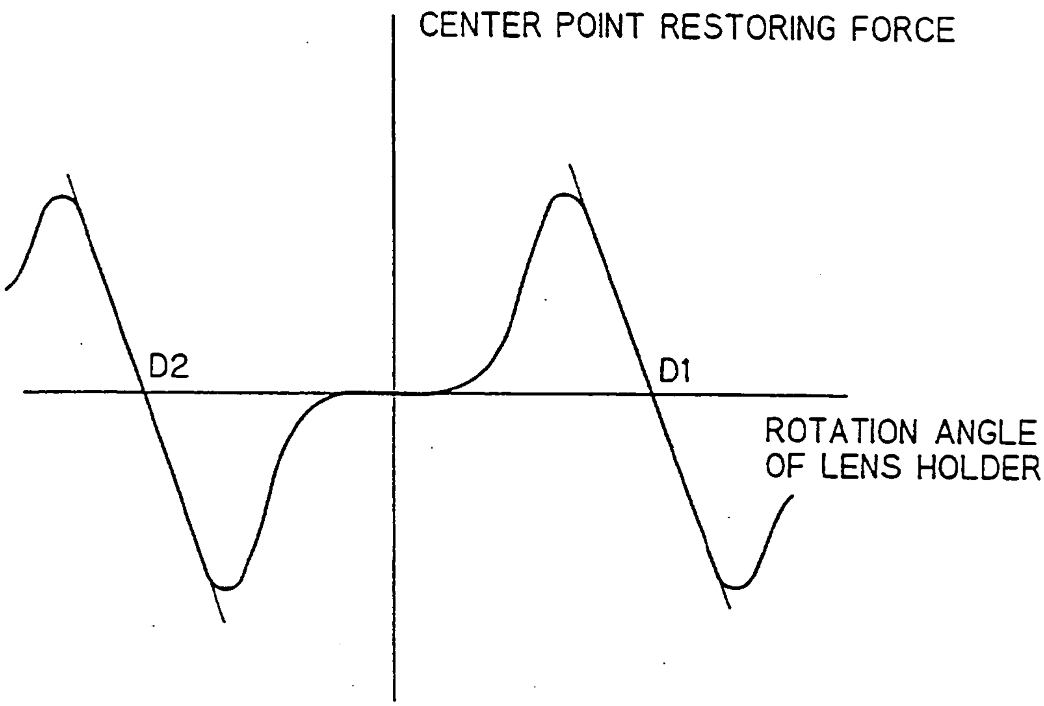
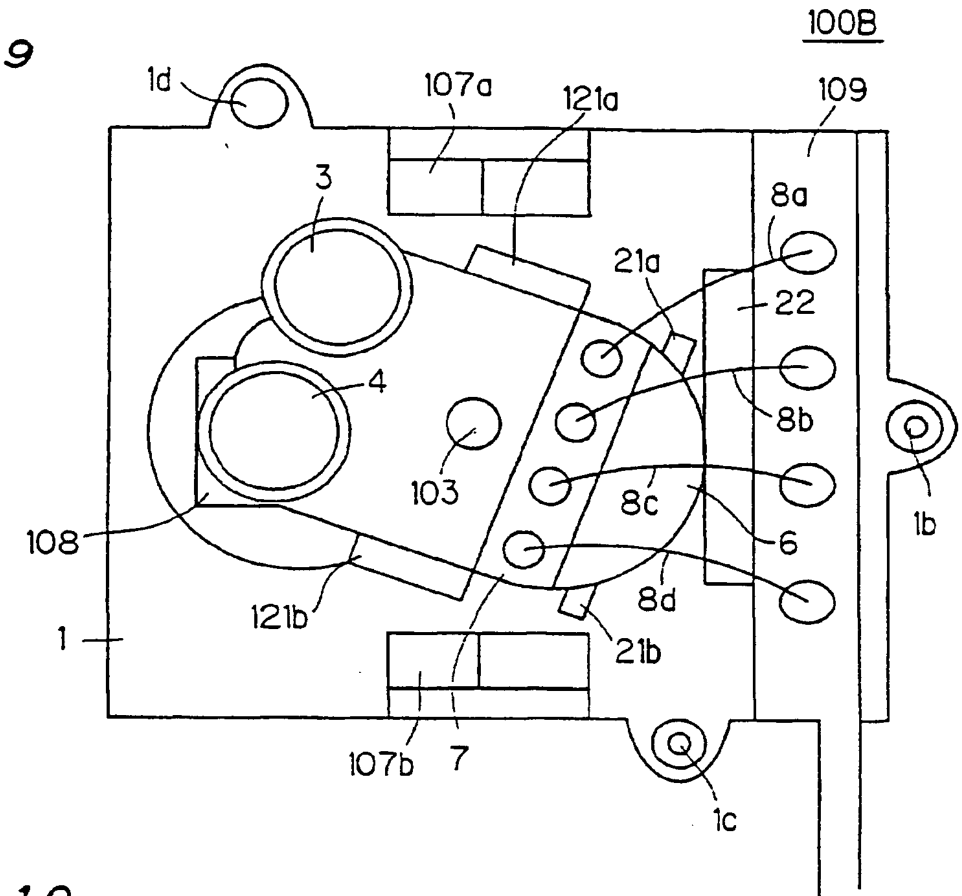

CENTER POINT RESTORING FORCE
D2
D1
ROTATION ANGLE
OF LENS HOLDER

FIG.9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107a
121a
109
3
8a
21a
22
4
8b
1b
103
8c
6
108
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1
21b
107b
7
1c

FIG.10

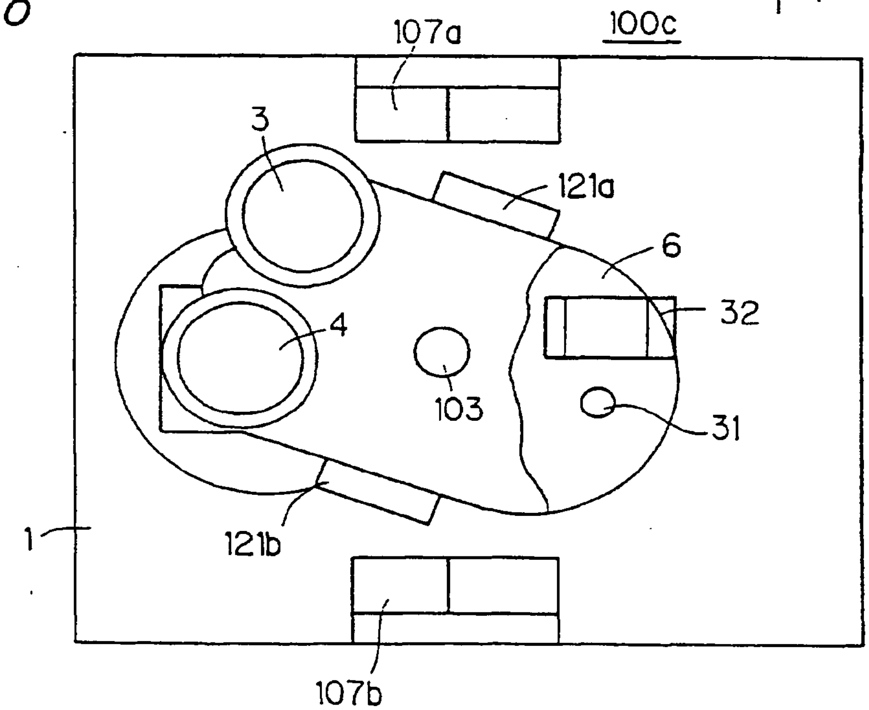

107a
100c
3
121a
6
32
4
103
31
1
121b
107b

FIG. 11

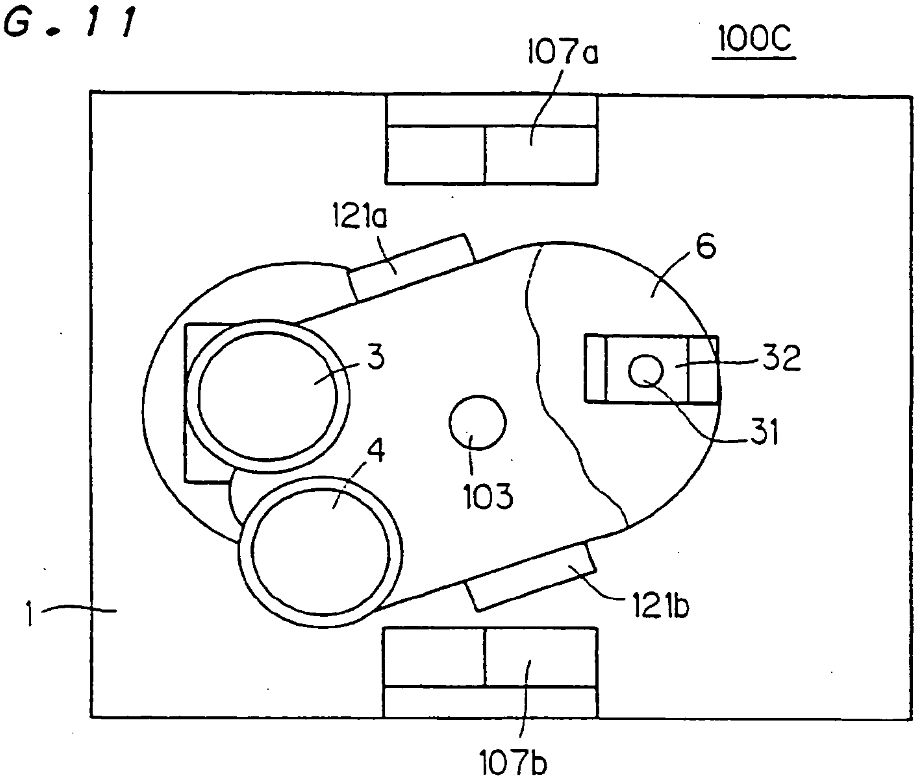

107a
100C
121a
6
3
32
31
4
103
1
121b
107b

FIG. 12

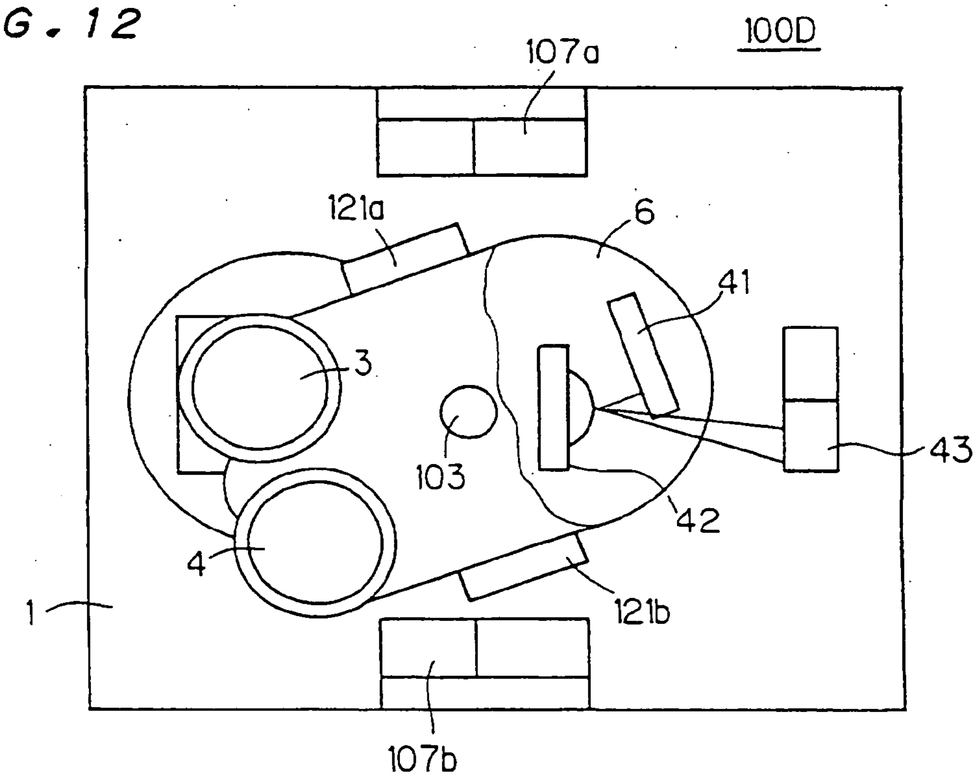

100D
107a
121a
6
41
3
103
43
42
4
1
121b
107b

FIG. 13

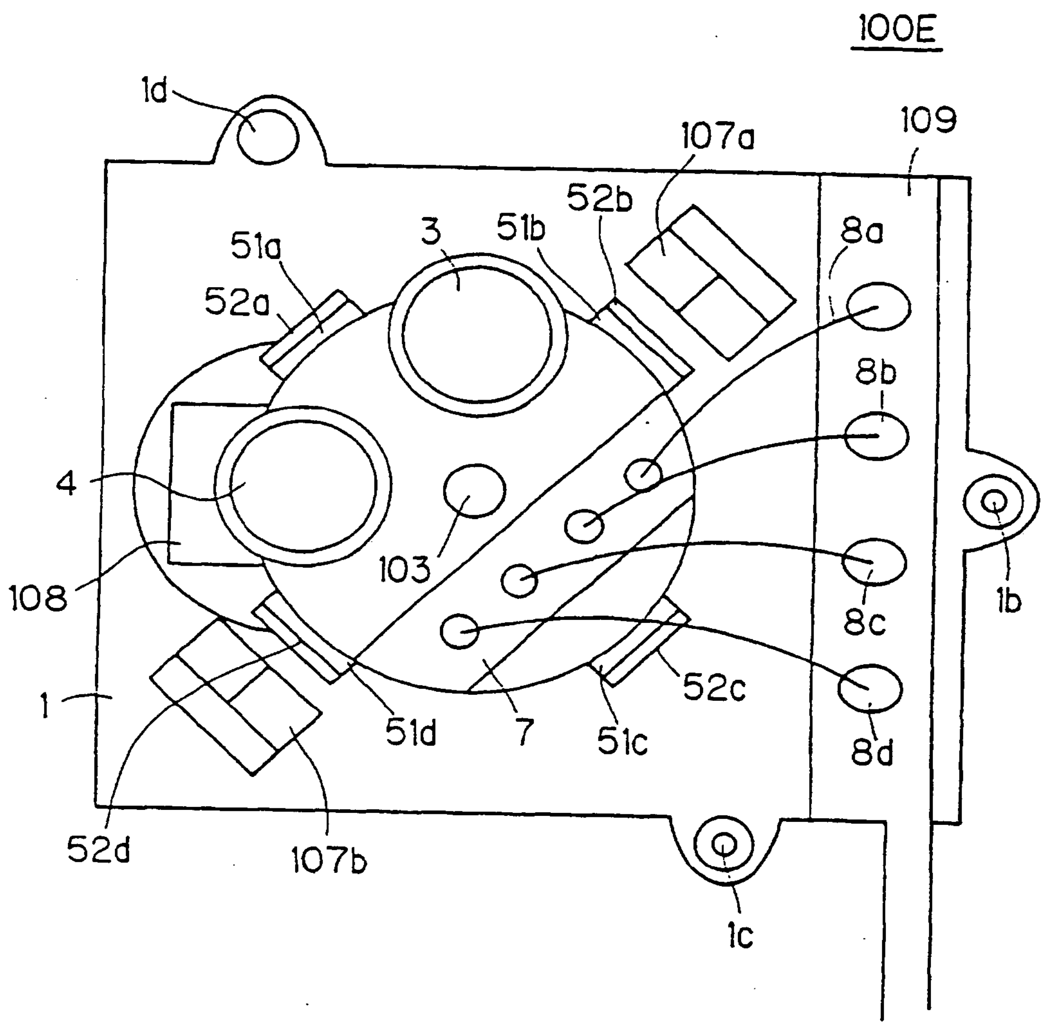

100E
1d
107a
109
52b
3
51b
8a
51a
52a
8b
4
1b
103
108
8c
52c
1
51d
7
51c
8d
52d
107b
1c

FIG. 14

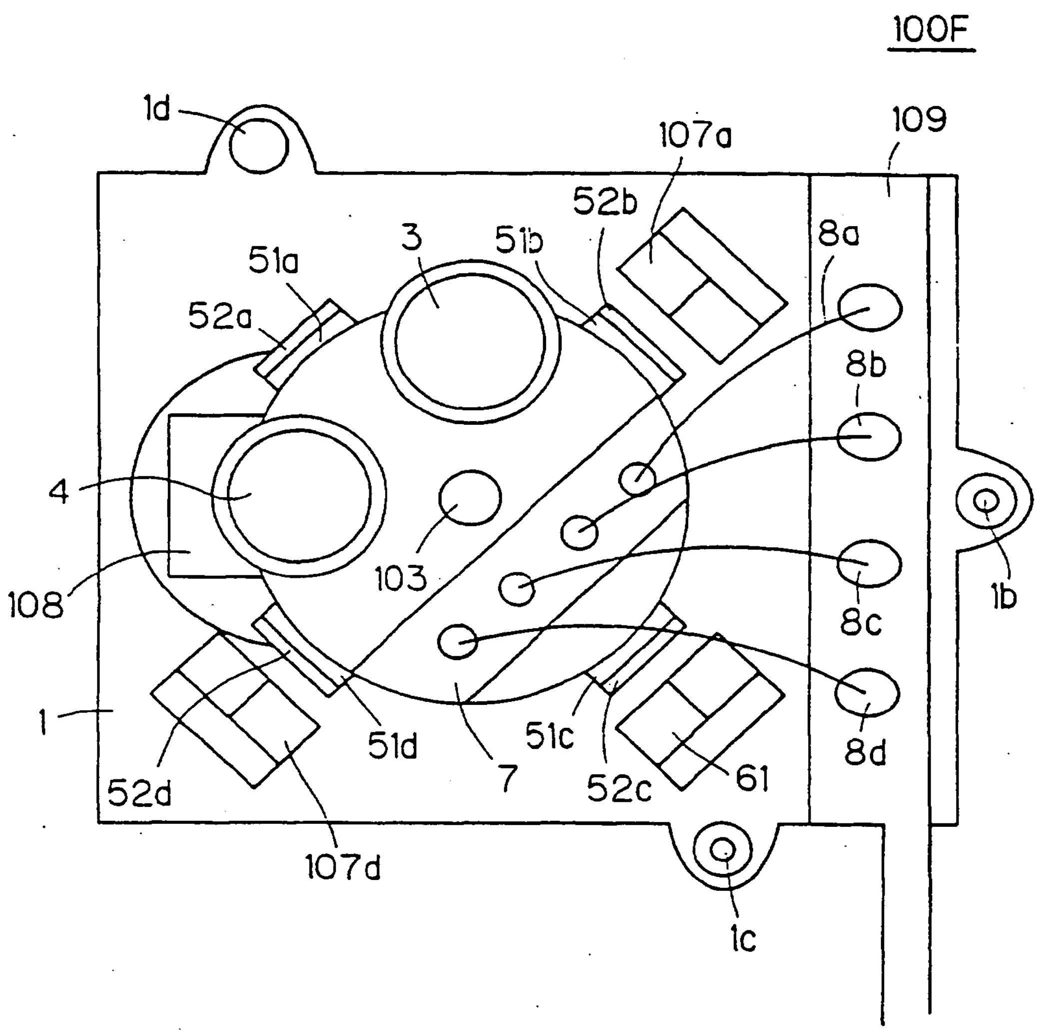
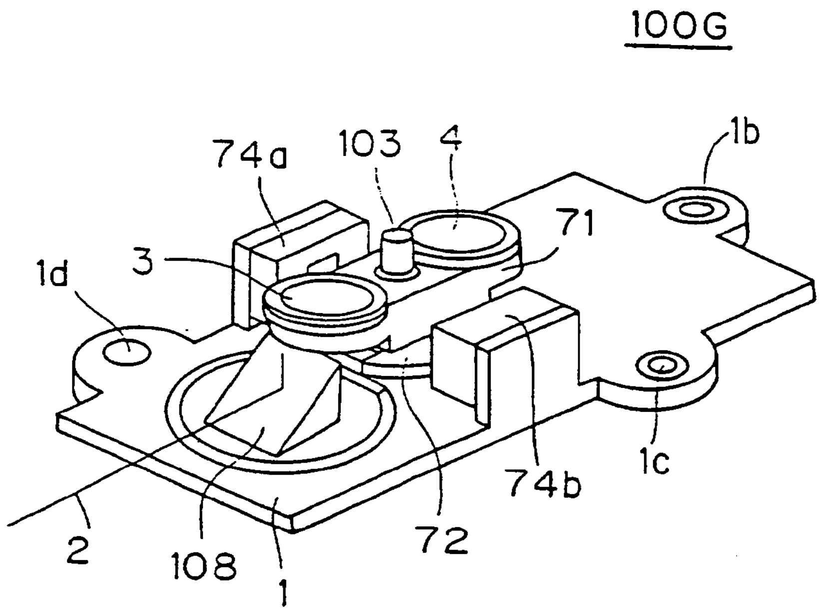

100F
1d
107a
109
52b
8a
3
51b
51a
52a
8b
4
103
108
8c
1b
1
51d
7
51c
52c
61
8d
52d
107d
1c

FIG. 15



F I G. 16

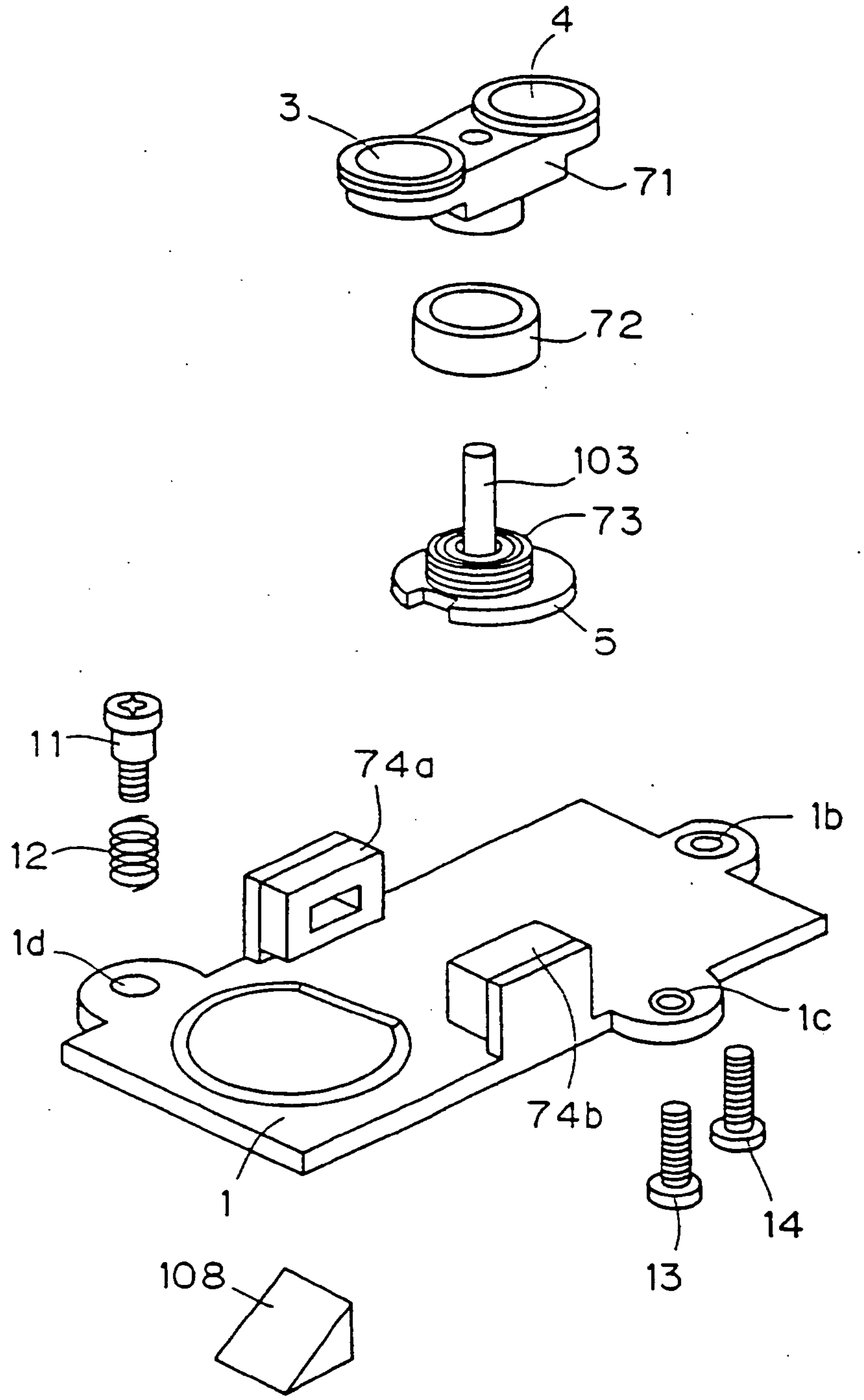


FIG. 17

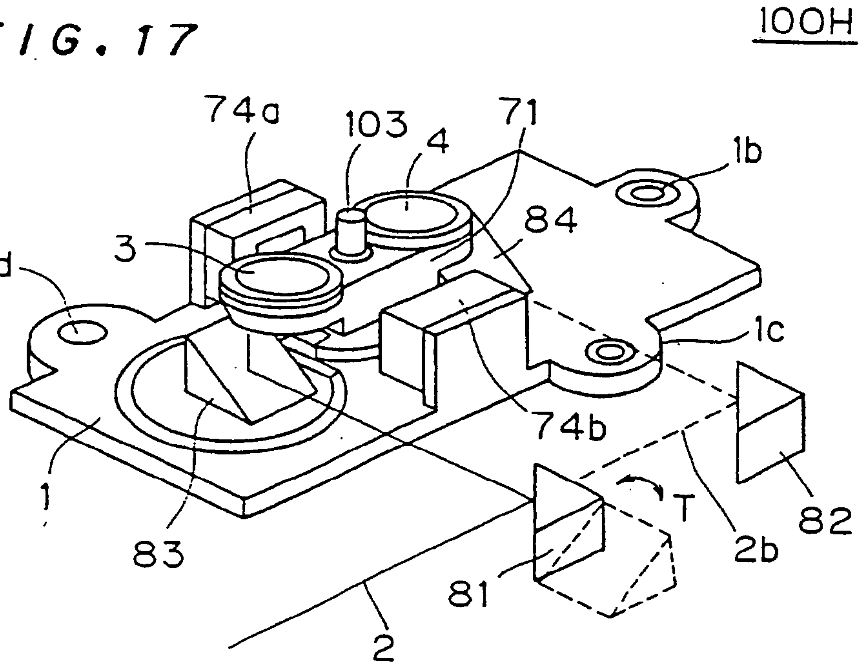

100H
74a
103
4
71
1b
84
3
1d
1c
74b
T
1
83
81
2b
82
2

FIG. 18

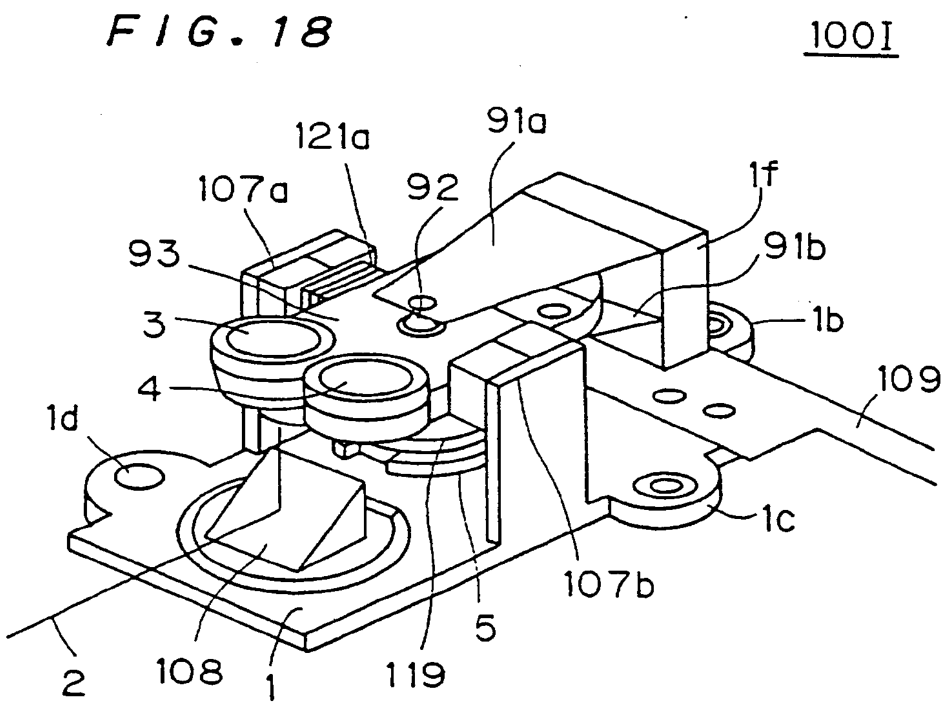

100I
91a
121a
107a
92
1f
93
91b
3
1b
4
109
1d
1c
107b
5
2
108
1
119

FIG. 19

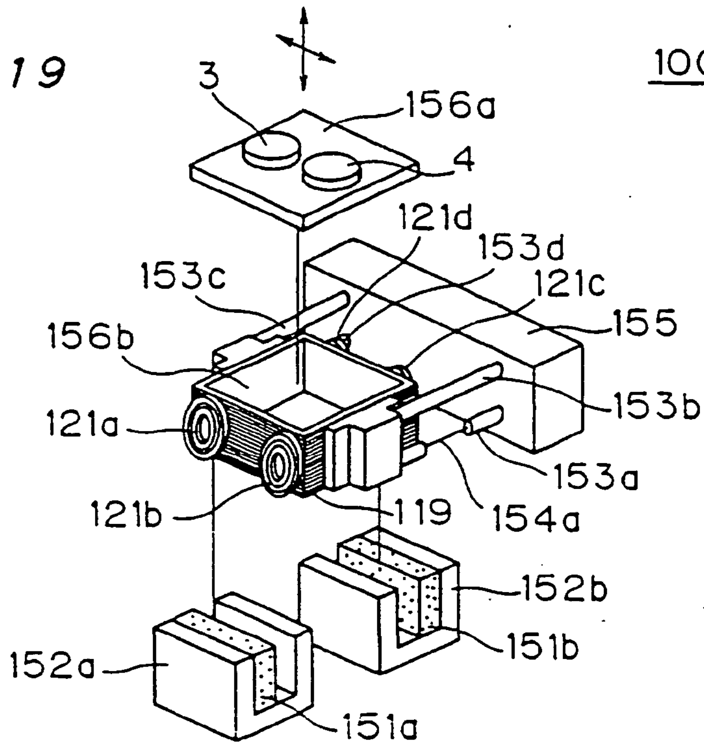

100J
3
156a
4
121d
153d
153c
121c
155
156b
153b
121a
153a
121b
119
154a
152b
151b
152a
151a

FIG. 20

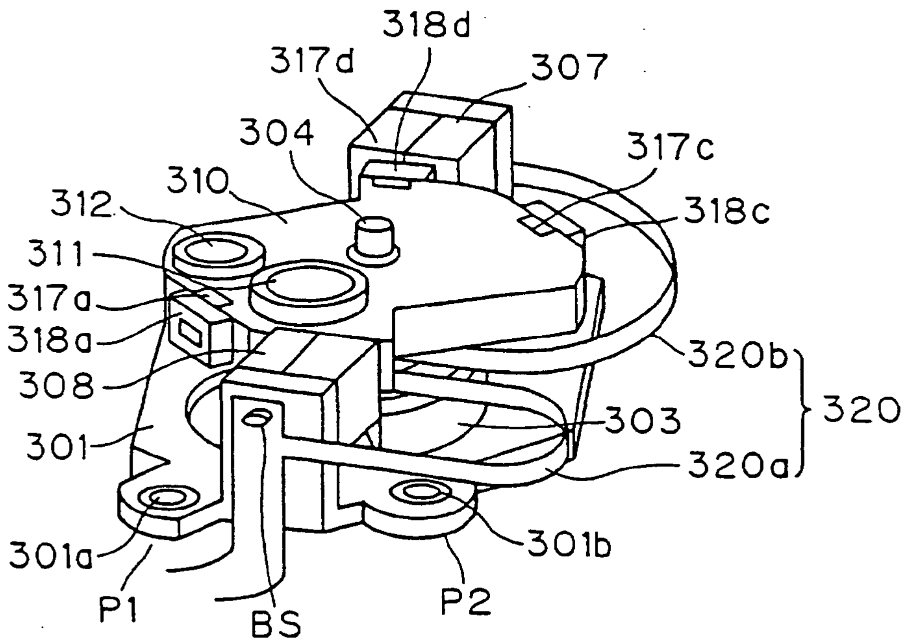

100K
318d
317d
307
304
317c
310
312
318c
311
317a
318a
320b
308
320
303
301
320a
301a
301b
P1
BS
P2

FIG. 21

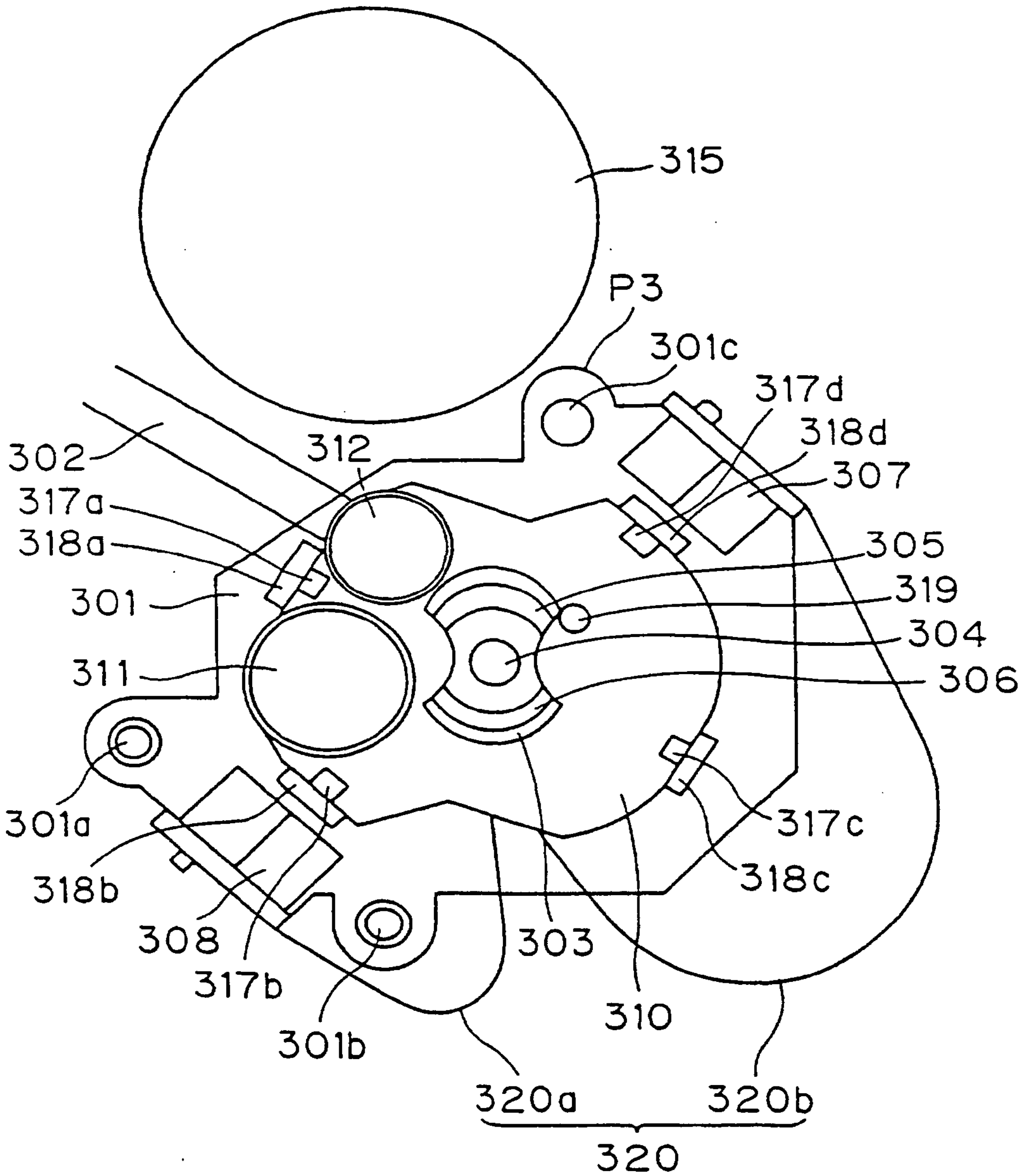

315
P3
301c
317d
318d
307
302
312
317a
318a
305
319
301
304
311
306
301a
317c
318b
318c
308
303
317b
310
301b
320a
320b
320

FIG.22

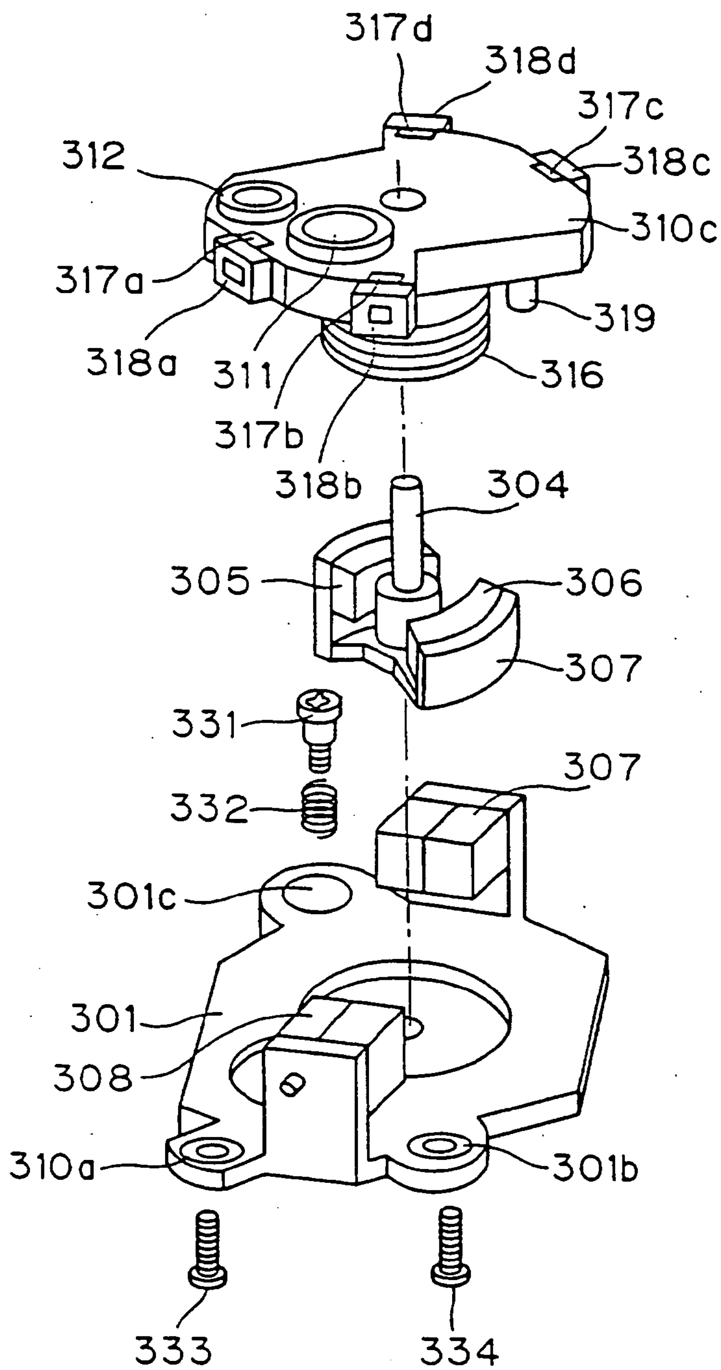

317d
318d
317c
312
318c
310c
317a
319
318a
311
316
317b
318b
304
305
306
307
331
307
332
301c
301
308
310a
301b
333
334

FIG. 23

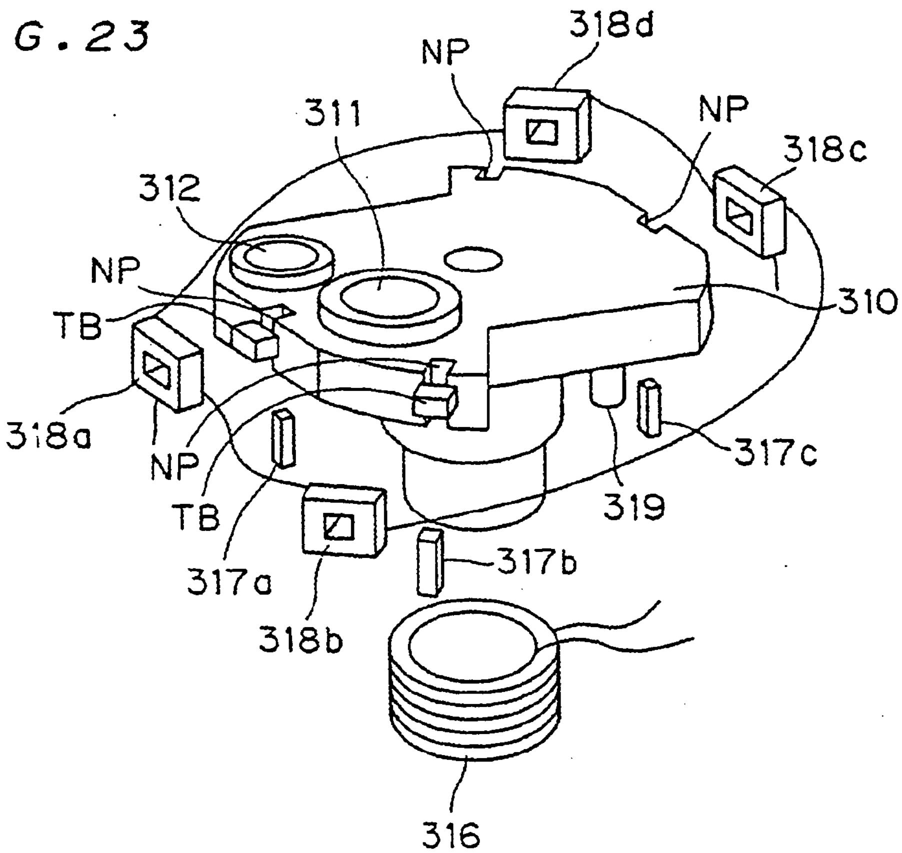

NP
318d
311
NP
318c
312
NP
310
TB
318a
NP
317c
319
TB
317a
317b
318b
316

FIG. 24

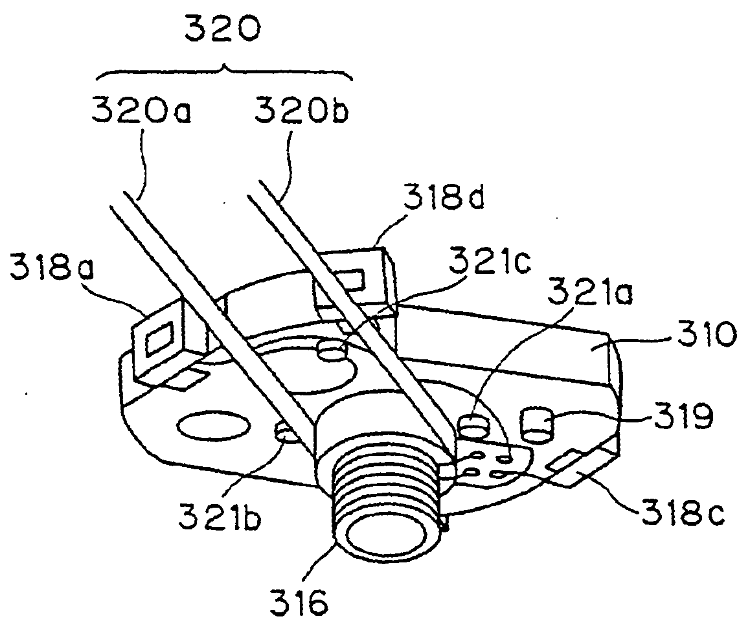

320
320a
320b
318d
318a
321c
321a
310
319
318c
321b
316

FIG. 25

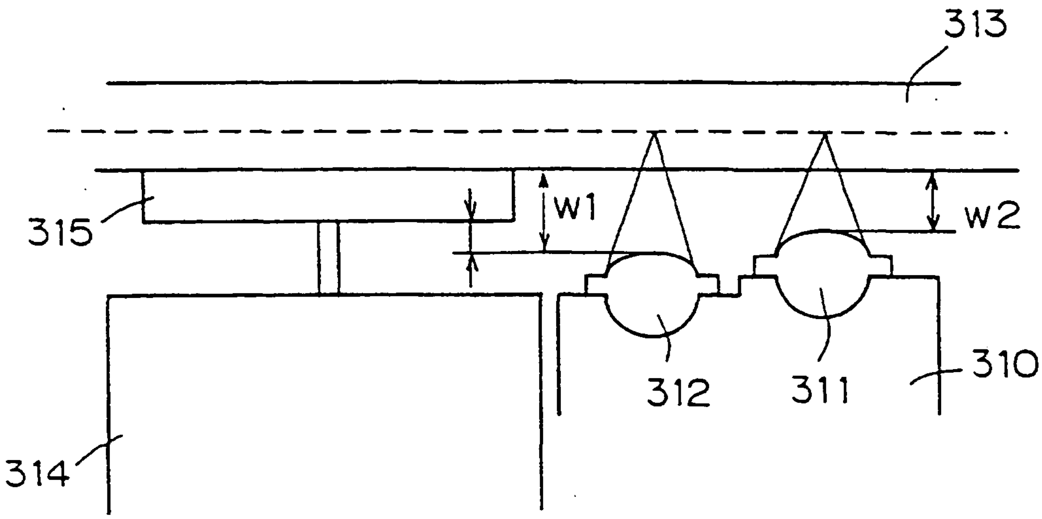

313
315
W1
W2
310
312
311
314

FIG. 26

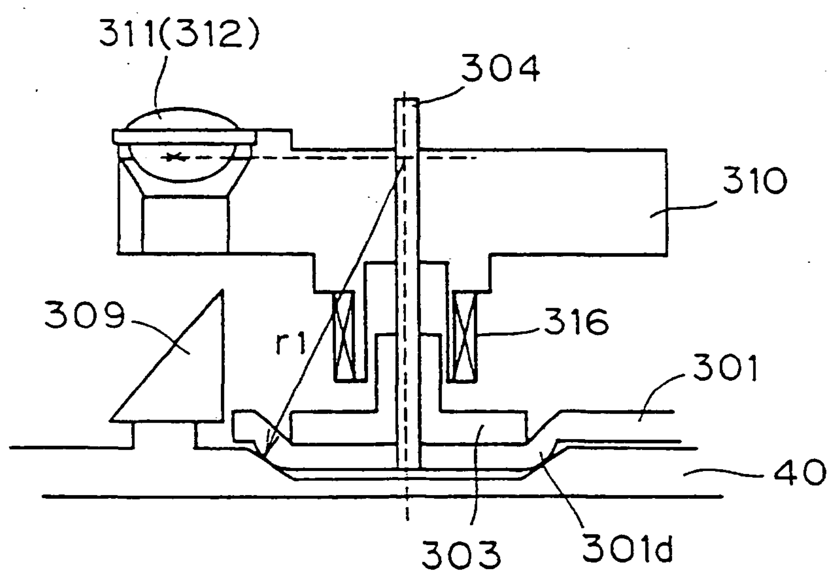

311(312)
304
310
309
316
r1
301
40
303
301d

FIG.27

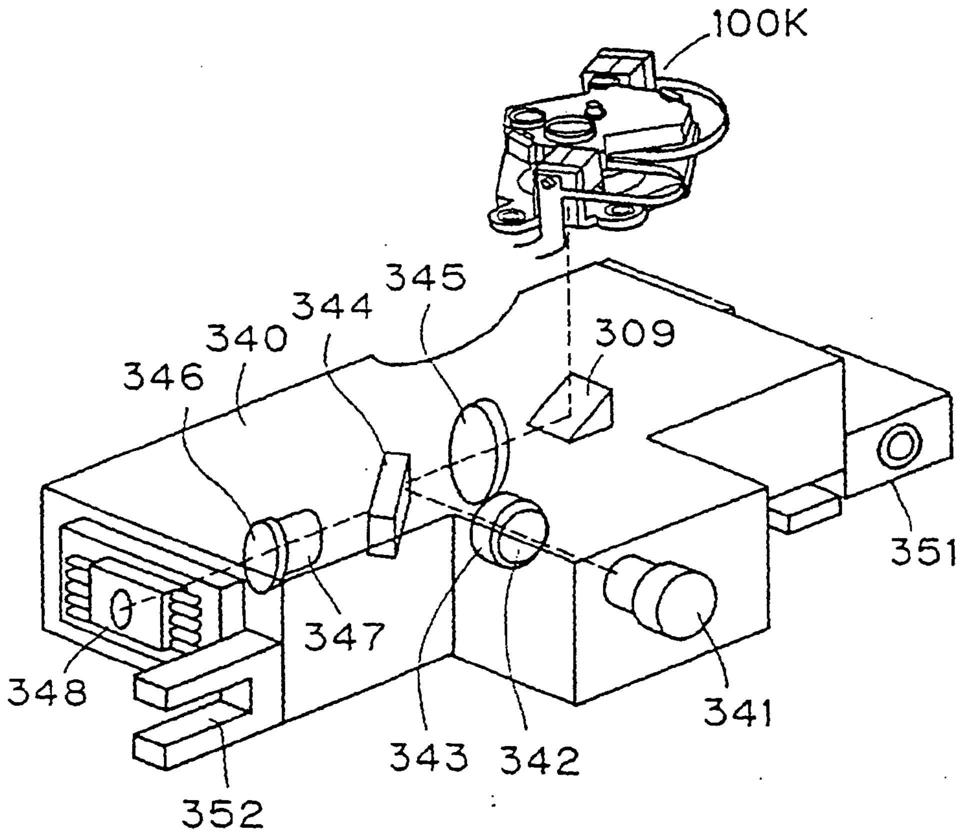


FIG. 28

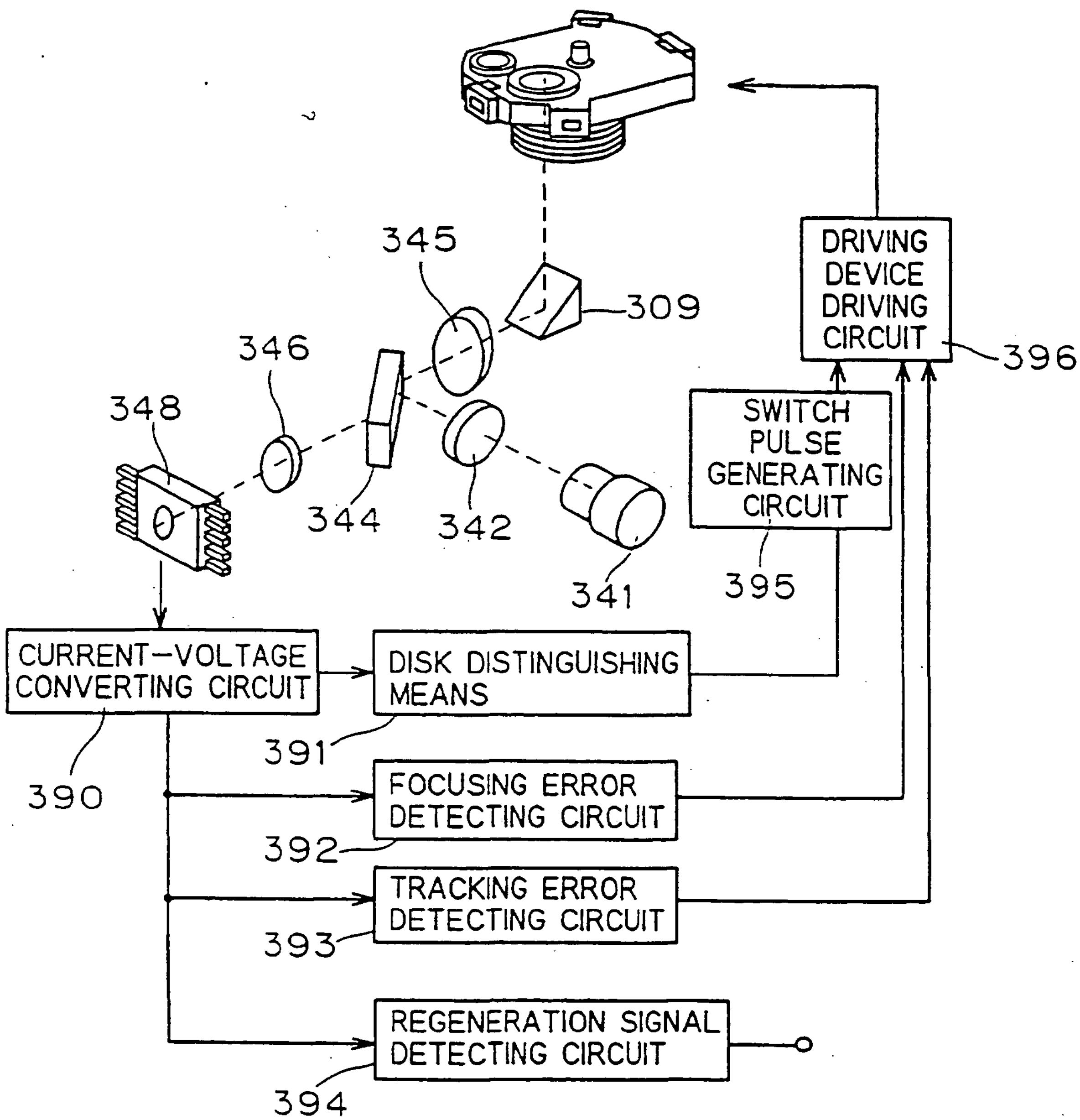

345
309
346
348
344
342
341
DRIVING DEVICE DRIVING CIRCUIT
396
SWITCH PULSE GENERATING CIRCUIT
395
CURRENT-VOLTAGE CONVERTING CIRCUIT
390
DISK DISTINGUISHING MEANS
391
FOCUSING ERROR DETECTING CIRCUIT
392
TRACKING ERROR DETECTING CIRCUIT
393
REGENERATION SIGNAL DETECTING CIRCUIT
394

FIG.29(a)

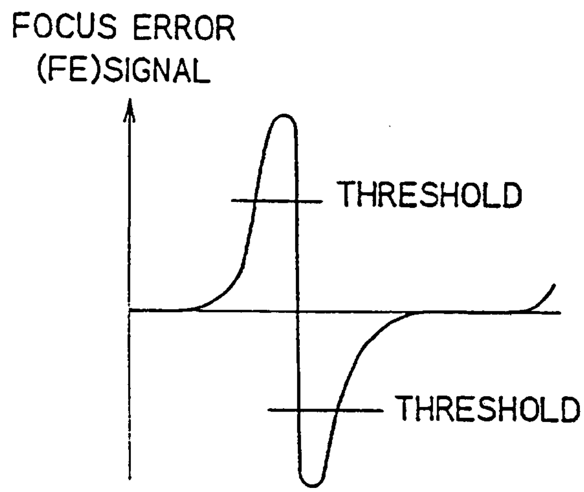


FIG.29(b)

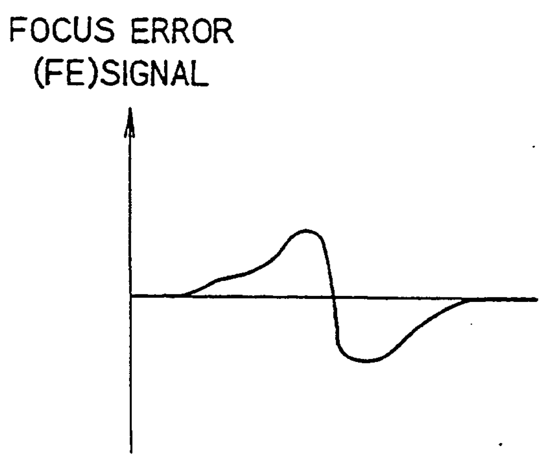


FIG. 30

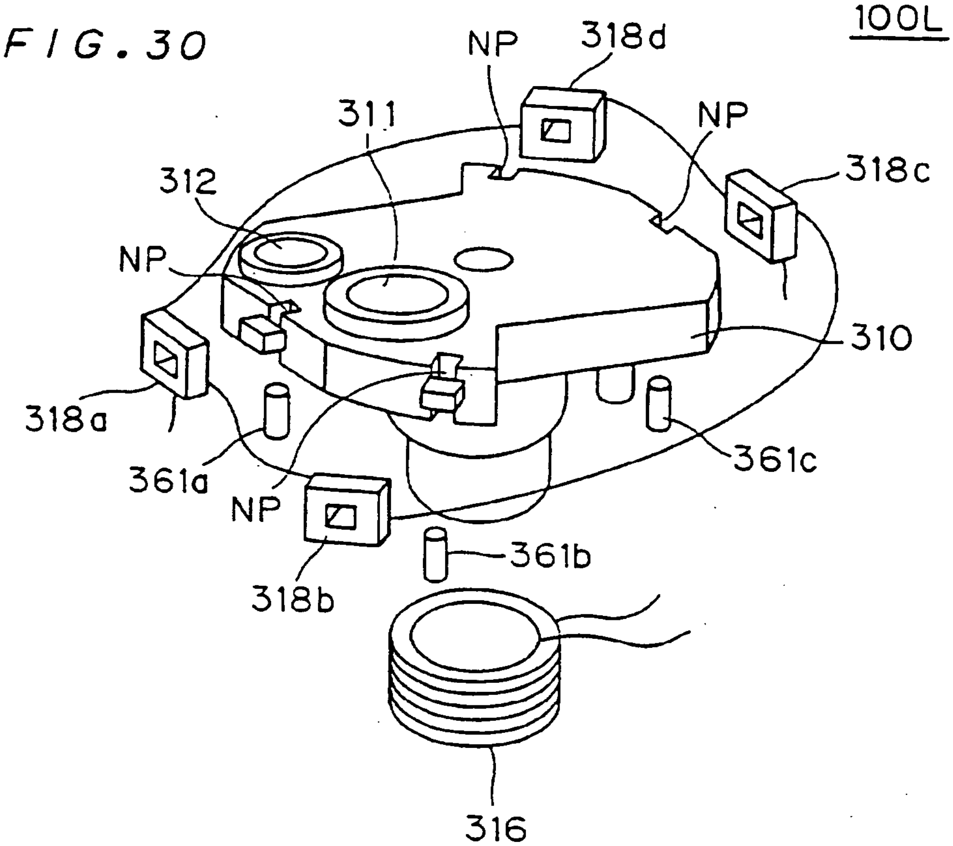
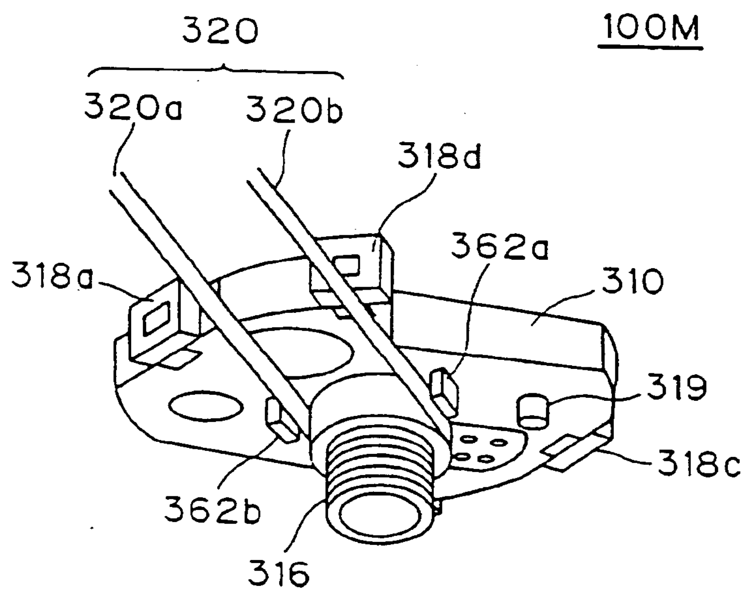
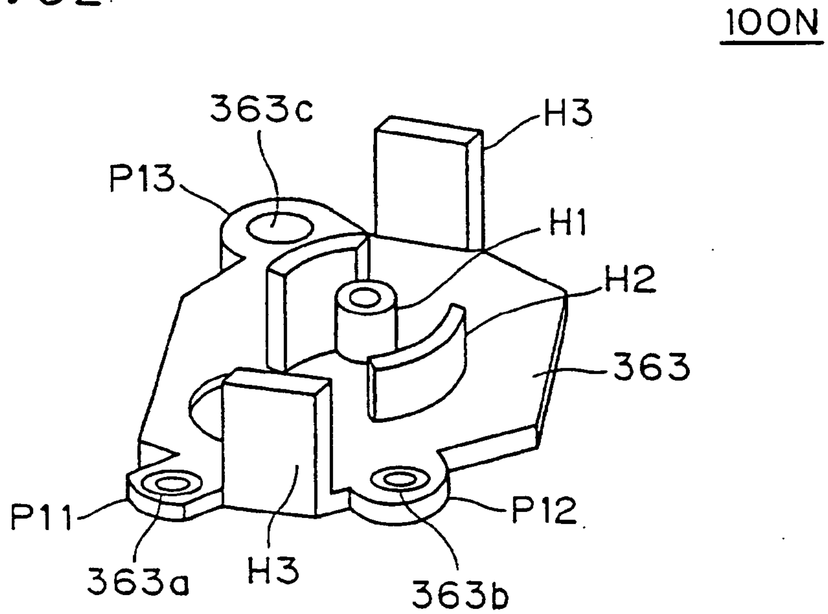

100L
NP
318d
311
NP
312
318c
NP
310
318a
361c
361a
NP
361b
318b
316

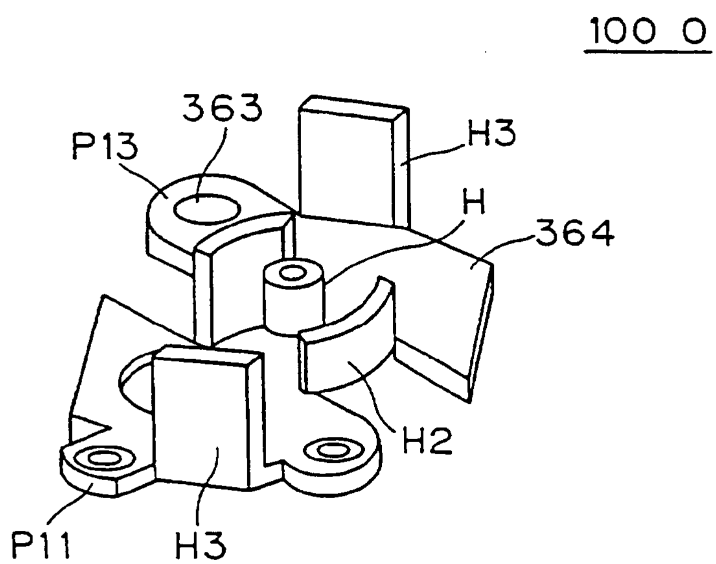
FIG. 31


320
100M
320a
320b
318d
362a
318a
310
319
318c
362b
316

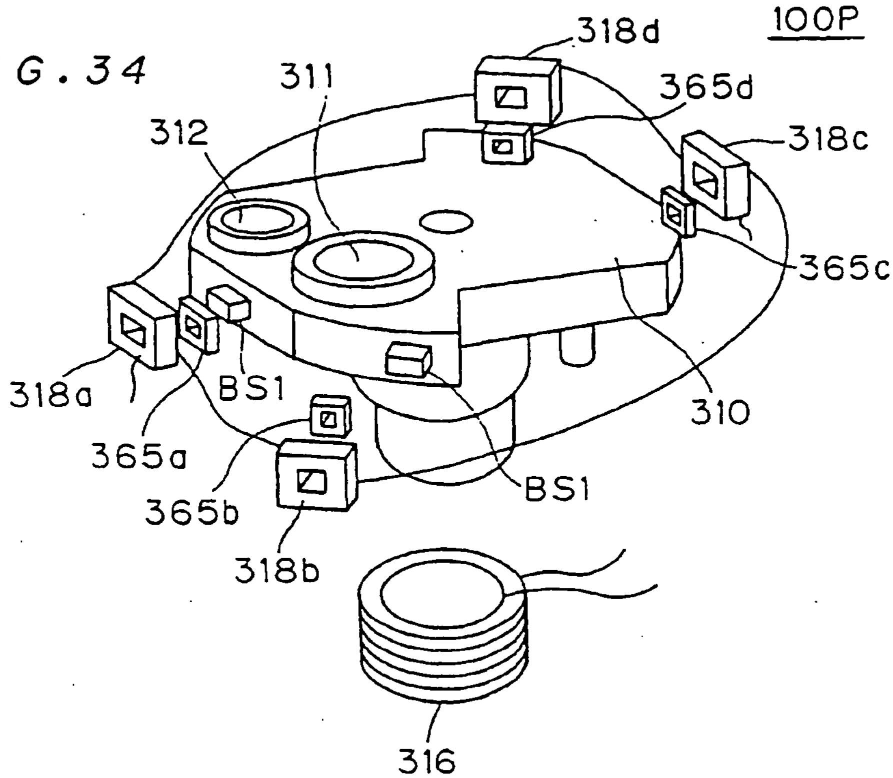
F I G. 32


100N
363c
H3
P13
H1
H2
363
P11
P12
363a
H3
363b

F I G. 33


100 O
363
P13
H3
H
364
H2
P11
H3

F I G . 34


100P
318d
311
365d
312
318c
365c
318a
BS1
310
365a
365b
BS1
318b
316

F I G . 35

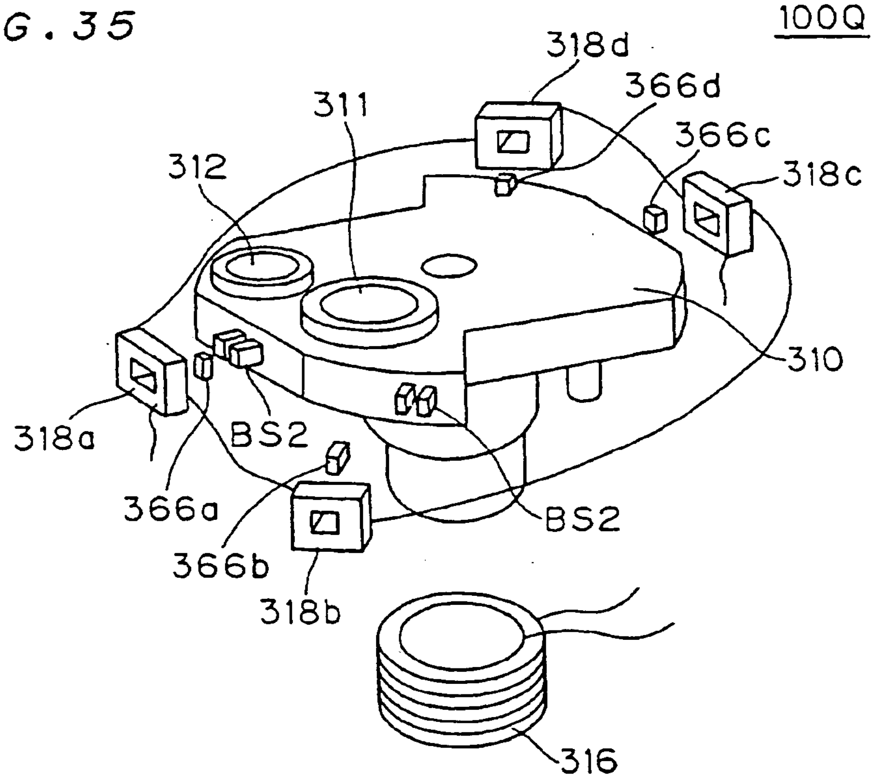

100Q
318d
366d
311
366c
312
318c
310
318a
BS2
366a
BS2
366b
318b
316

FIG. 36

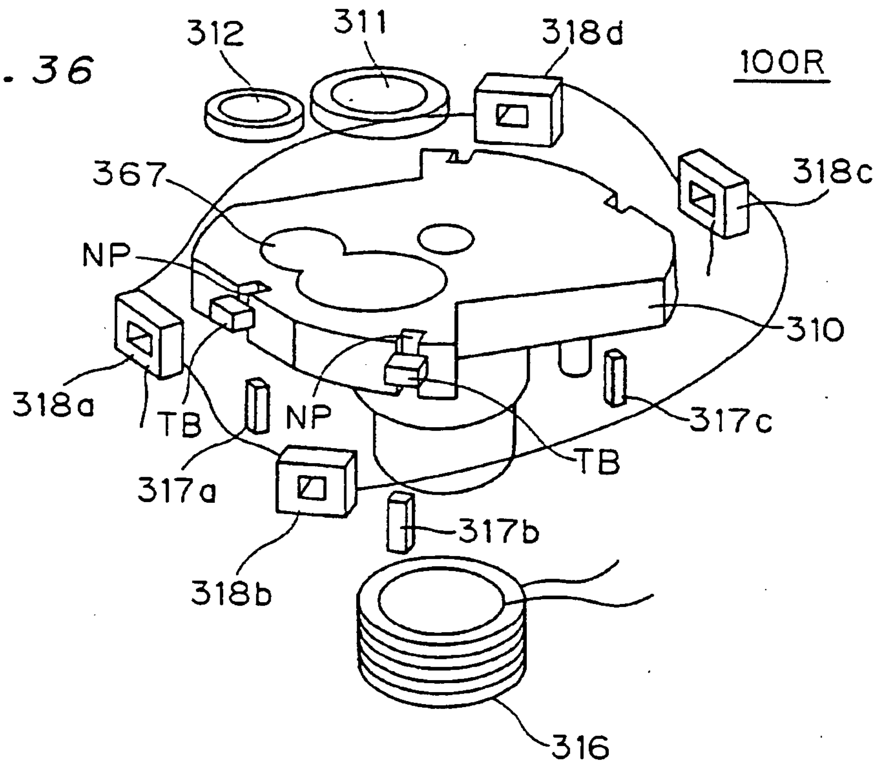

312
311
318d
100R
367
318c
NP
310
318a
TB
NP
317c
TB
317a
317b
318b
316

FIG. 37

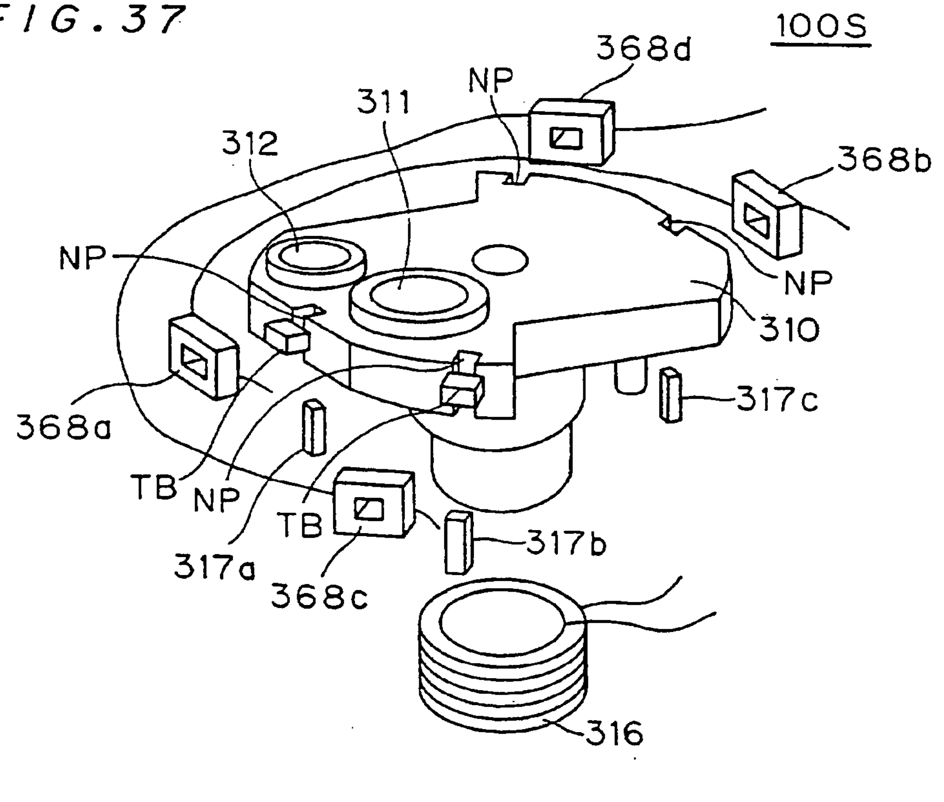
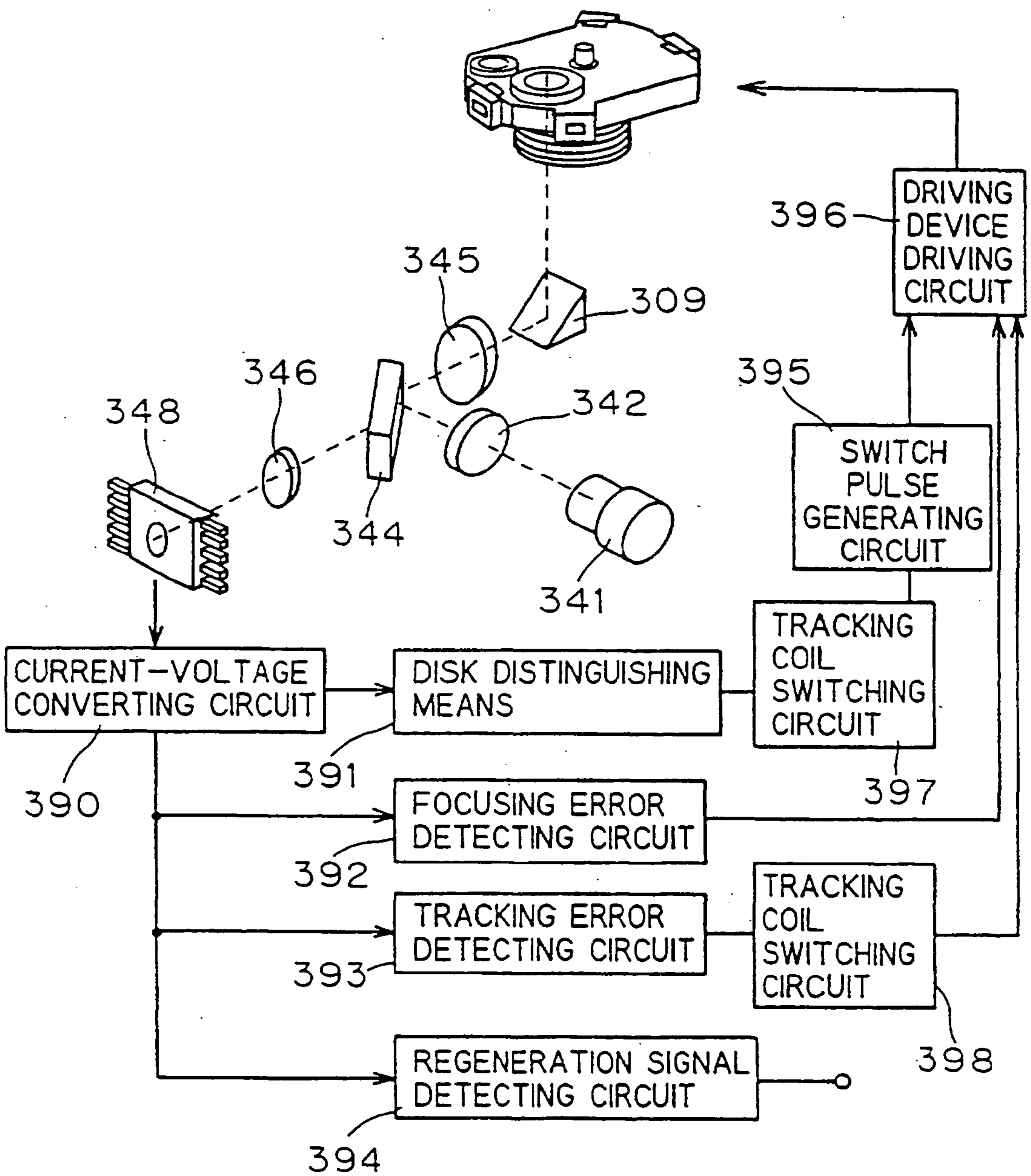

100S
368d
NP
311
312
368b
NP
NP
310
317c
368a
TB
NP
TB
317b
317a
368c
316

FIG. 38



345
309
346
348
342
344
341
396
DRIVING DEVICE DRIVING CIRCUIT
395
SWITCH PULSE GENERATING CIRCUIT
TRACKING COIL SWITCHING CIRCUIT
CURRENT-VOLTAGE CONVERTING CIRCUIT
DISK DISTINGUISHING MEANS
390
391
397
FOCUSING ERROR DETECTING CIRCUIT
392
TRACKING ERROR DETECTING CIRCUIT
TRACKING COIL SWITCHING CIRCUIT
393
398
REGENERATION SIGNAL DETECTING CIRCUIT
394

FIG.39

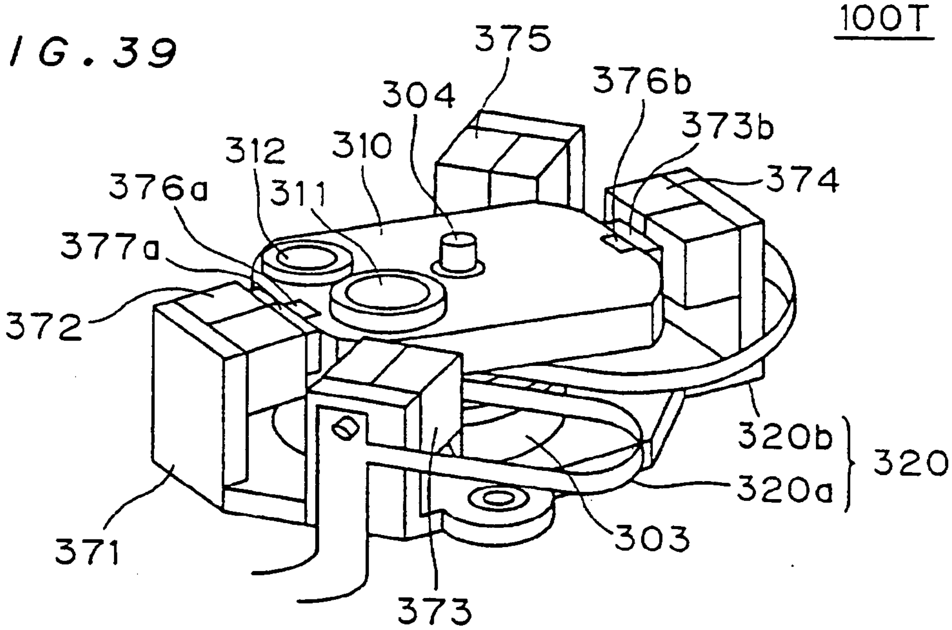

100T
375
376b
304
373b
312
310
374
376a
311
377a
372
320b
320
320a
303
371
373

FIG.40

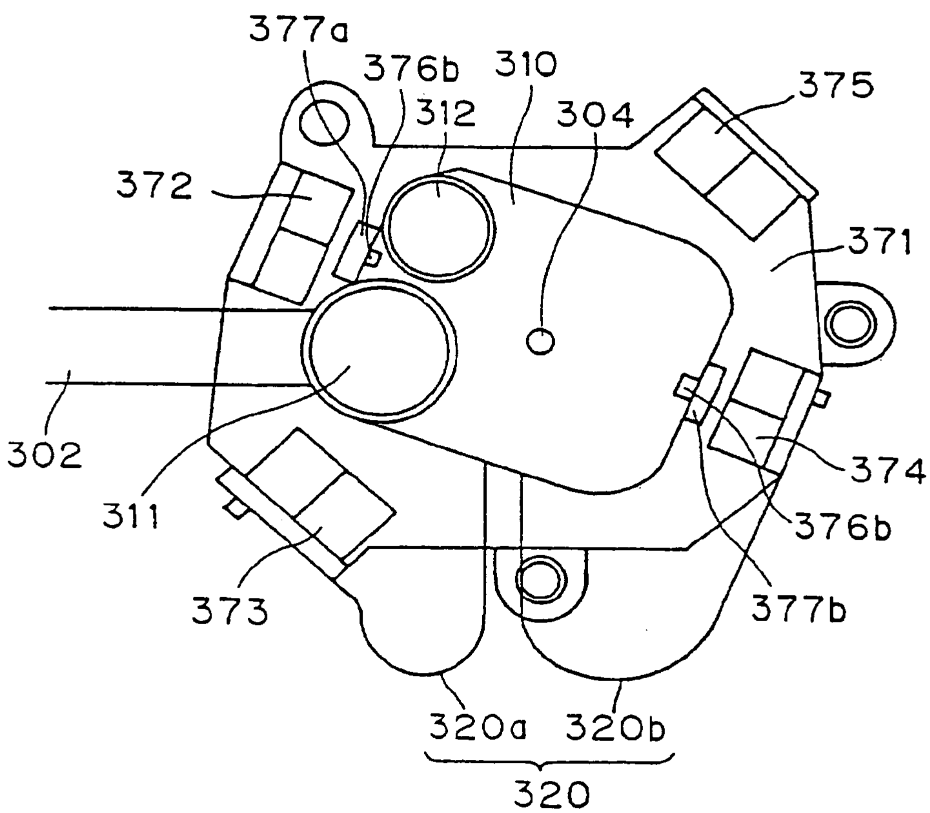

377a
376b
310
375
312
304
372
371
302
374
311
376b
373
377b
320a
320b
320

FIG. 41

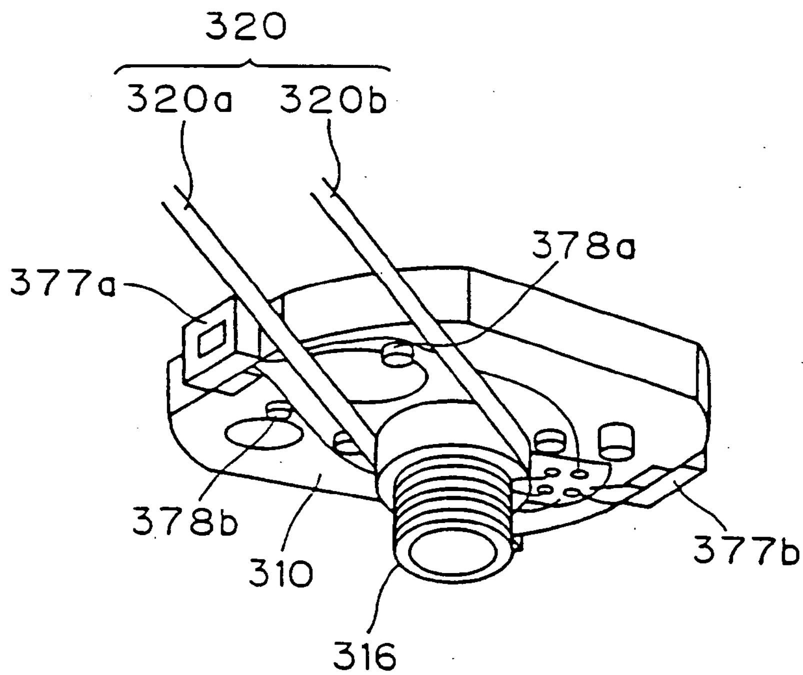


FIG. 42

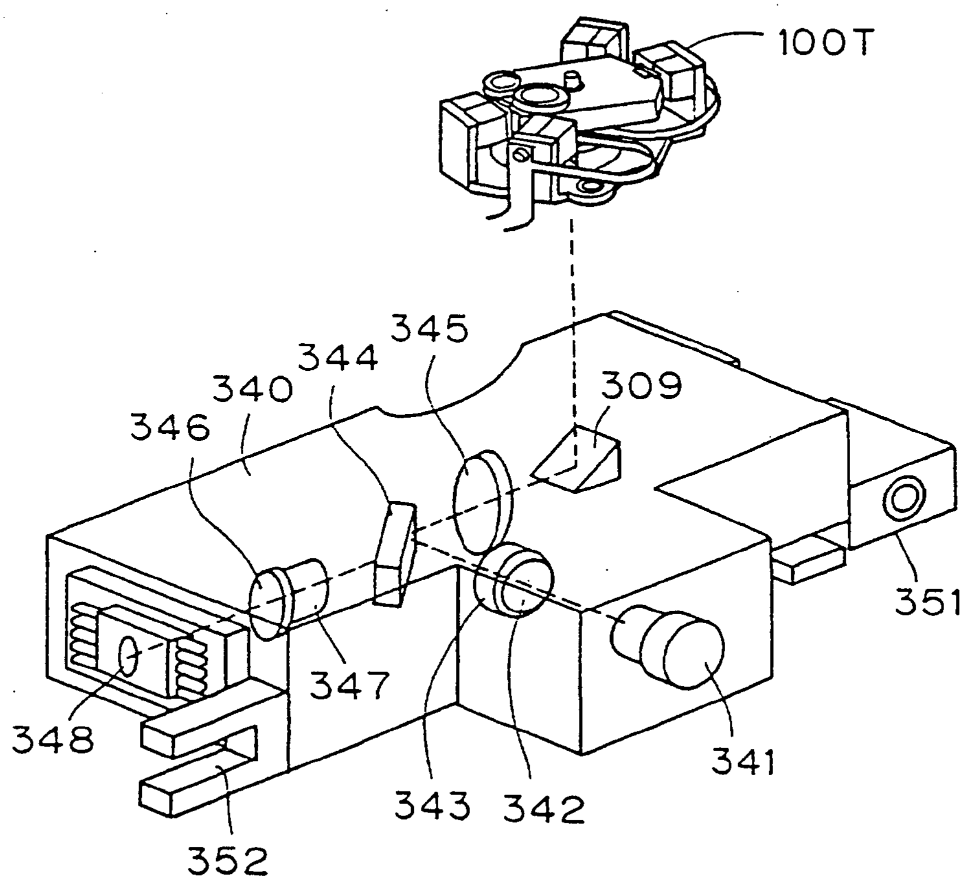


FIG. 43

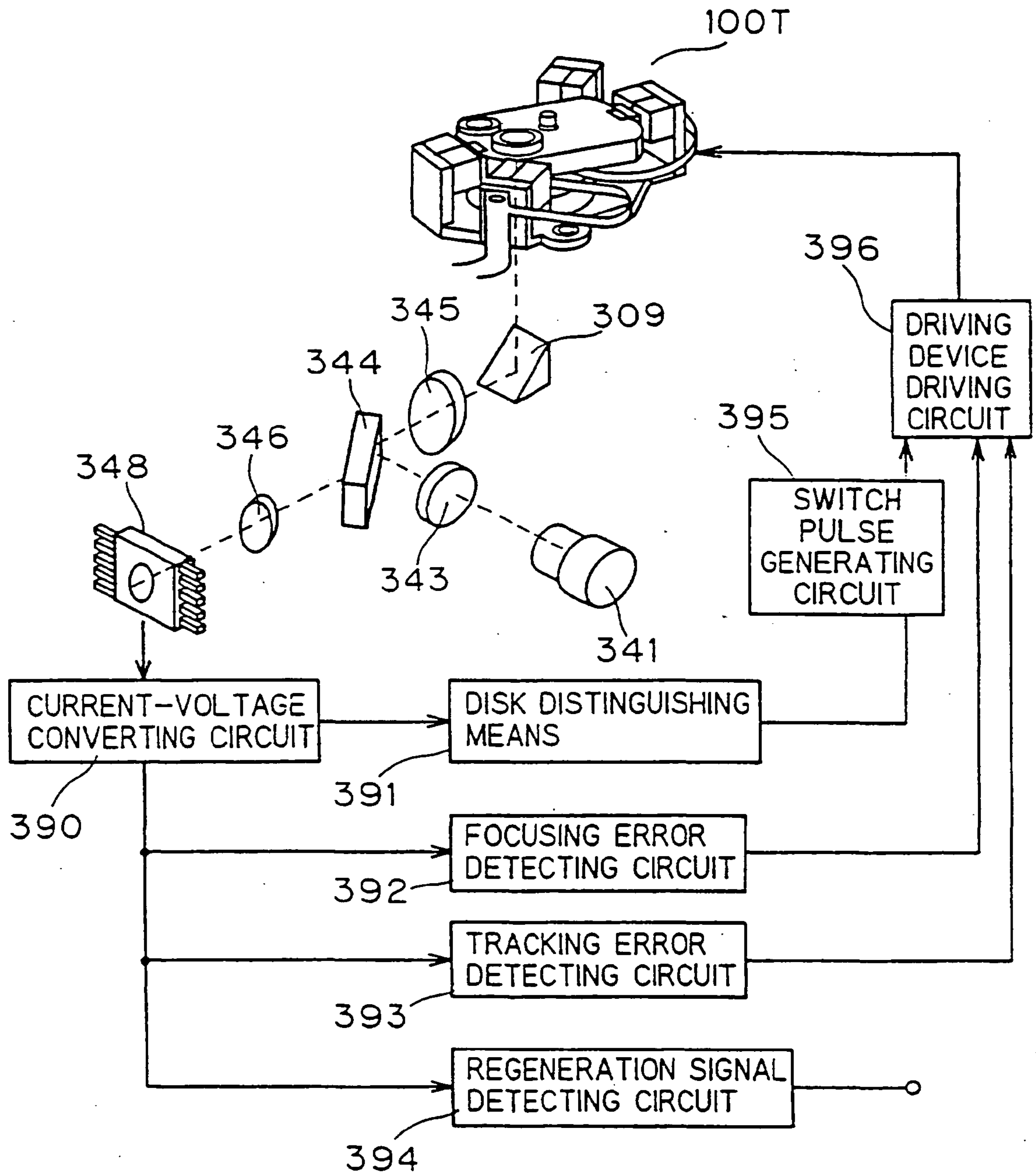

100T
396
DRIVING DEVICE DRIVING CIRCUIT
345
309
344
395
346
348
SWITCH PULSE GENERATING CIRCUIT
343
341
CURRENT-VOLTAGE CONVERTING CIRCUIT
DISK DISTINGUISHING MEANS
391
390
FOCUSING ERROR DETECTING CIRCUIT
392
TRACKING ERROR DETECTING CIRCUIT
393
REGENERATION SIGNAL DETECTING CIRCUIT
394

FIG.44

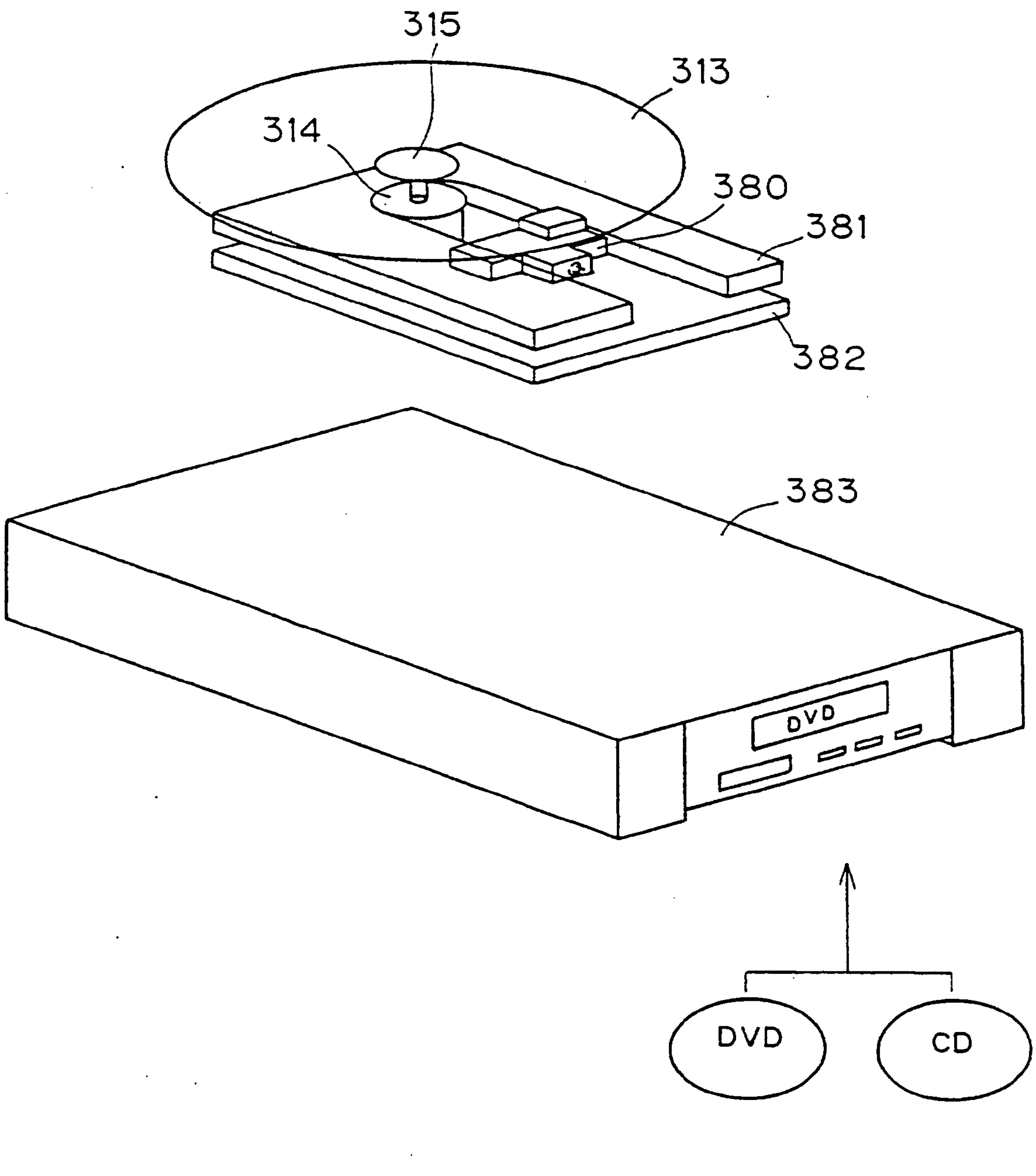


FIG. 45

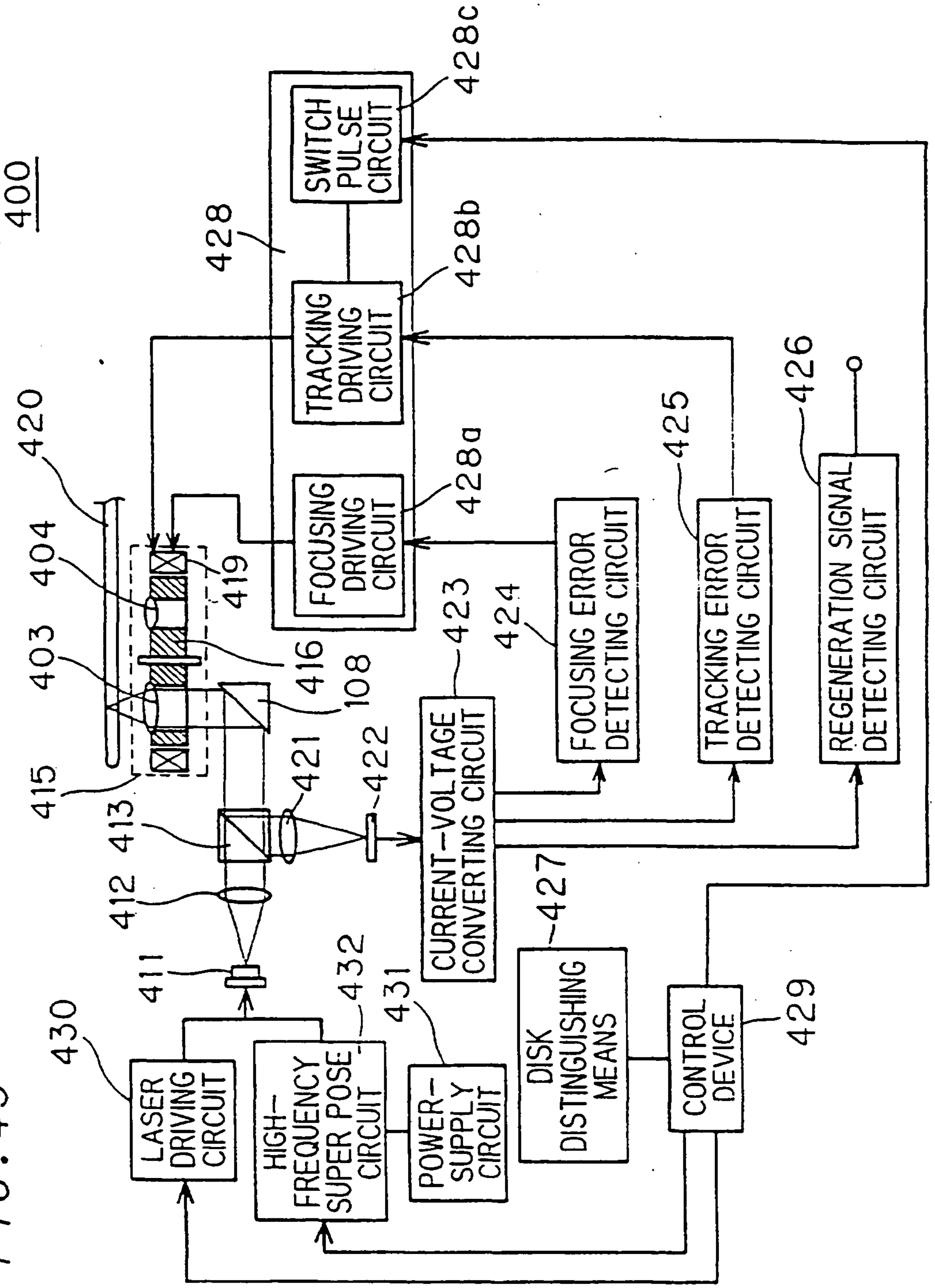

400
420
404
403
415
419
416
108
413
412
411
421
422
428
428a
428b
428c
SWITCH PULSE CIRCUIT
TRACKING DRIVING CIRCUIT
FOCUSING DRIVING CIRCUIT
423
CURRENT-VOLTAGE CONVERTING CIRCUIT
424
FOCUSING ERROR DETECTING CIRCUIT
425
TRACKING ERROR DETECTING CIRCUIT
426
REGENERATION SIGNAL DETECTING CIRCUIT
427
DISK DISTINGUISHING MEANS
429
CONTROL DEVICE
430
LASER DRIVING CIRCUIT
432
HIGH-FREQUENCY SUPER POSE CIRCUIT
431
POWER-SUPPLY CIRCUIT

FIG. 46

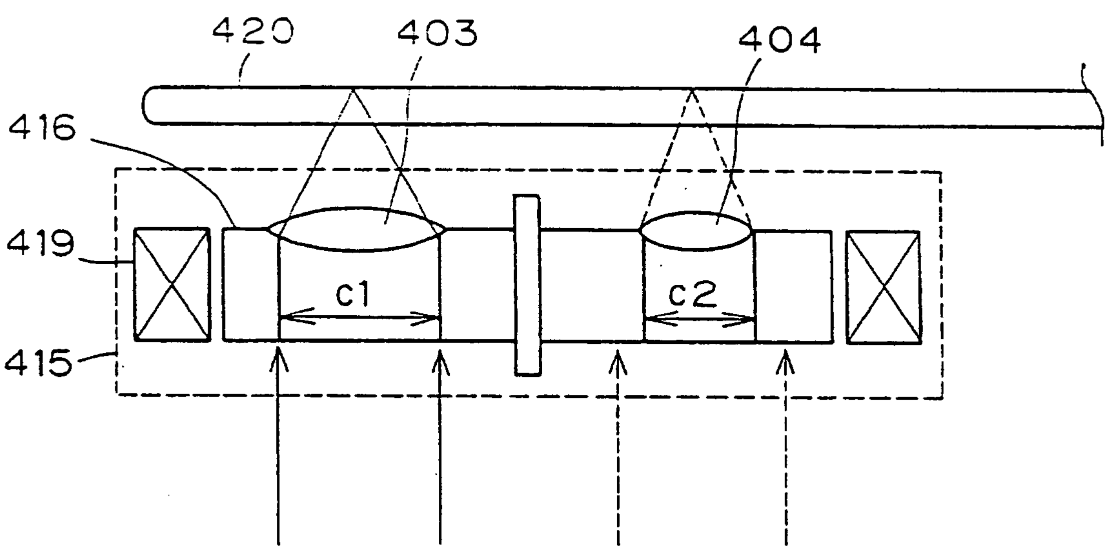


FIG.47(A)

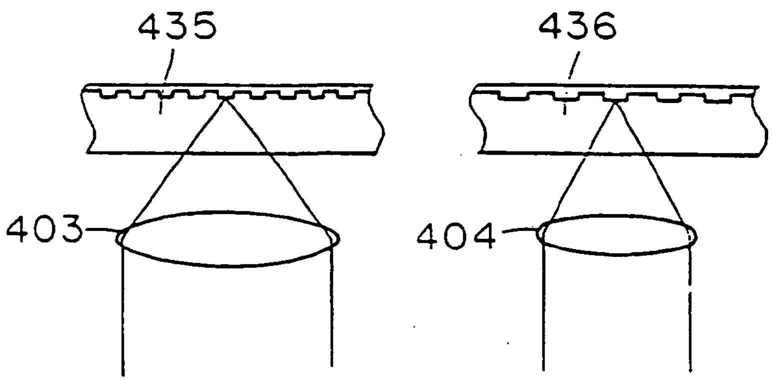


FIG.47(B)

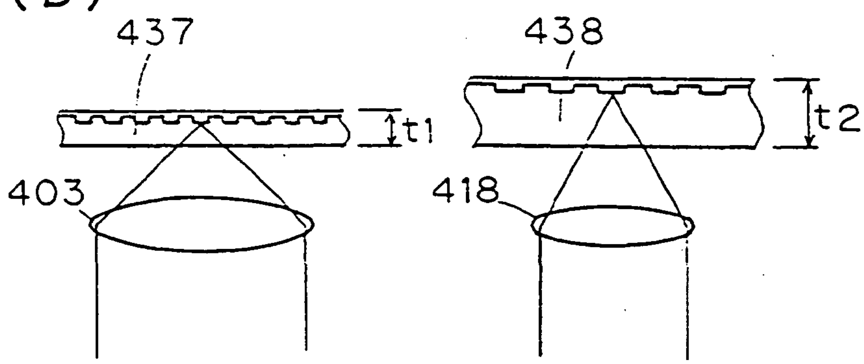


FIG.48(A)

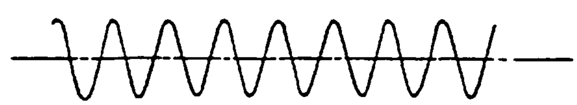


FIG.48(B)

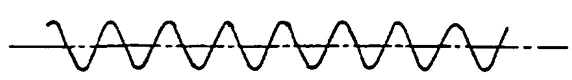


FIG. 49

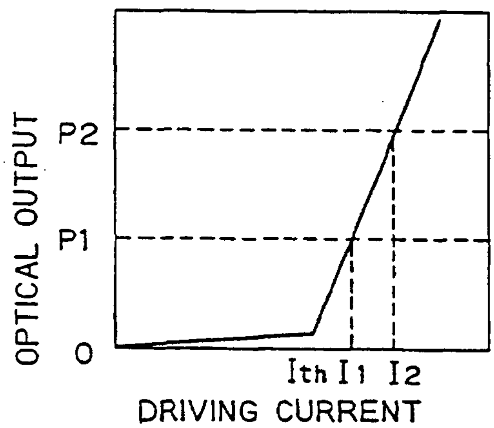


FIG. 50

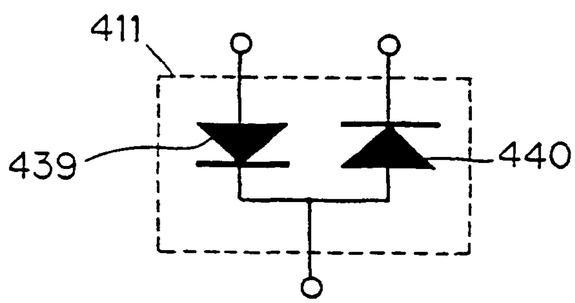


FIG.51

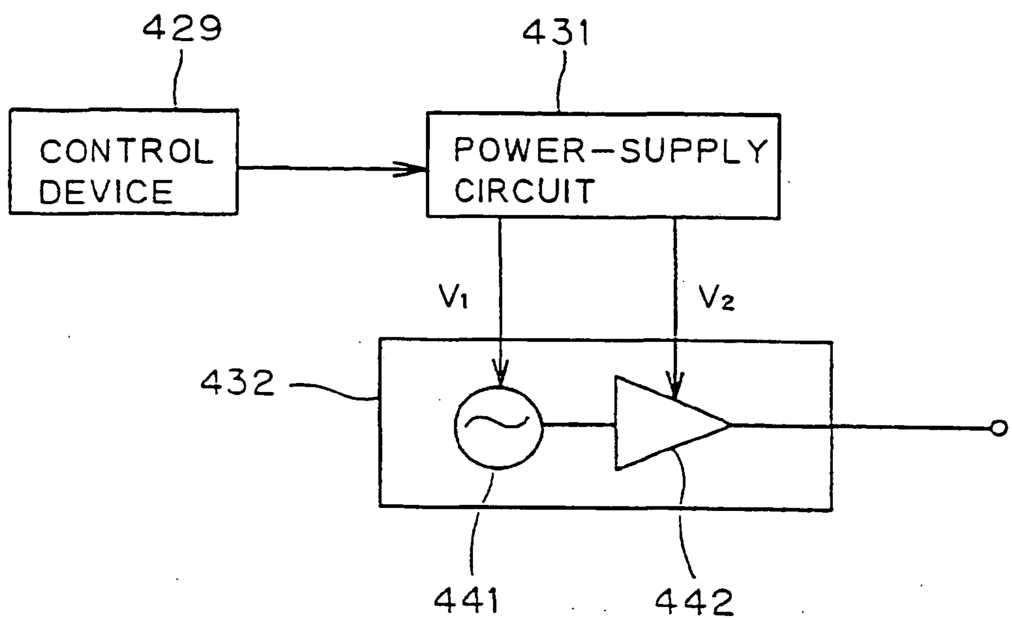

429
431
CONTROL DEVICE
POWER-SUPPLY CIRCUIT
V1
V2
432
441
442

FIG.52

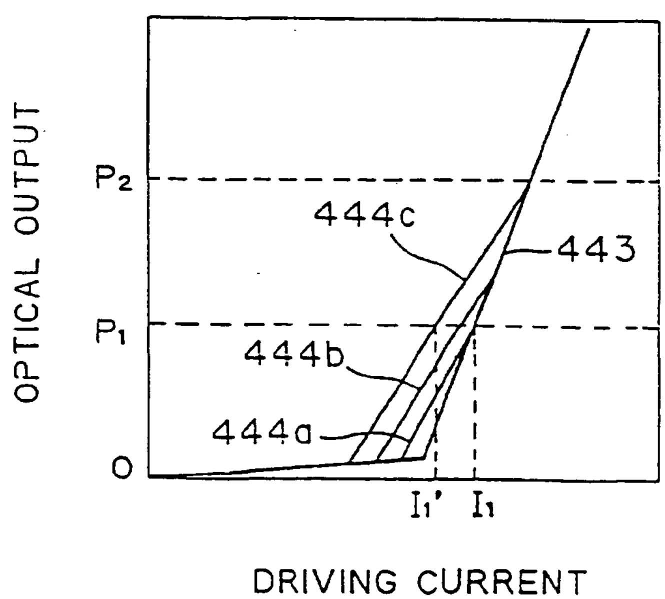

OPTICAL OUTPUT
P2
P1
O
444c
443
444b
444a
I1'
I1
DRIVING CURRENT

FIG. 53

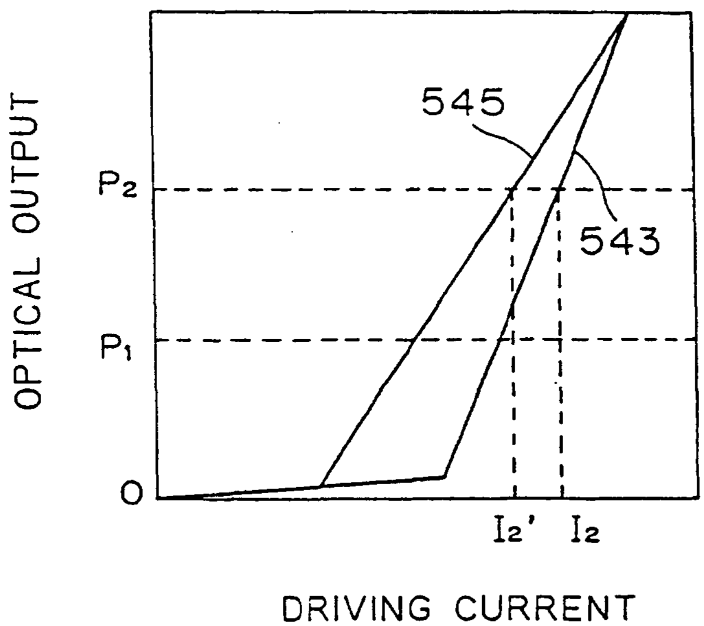
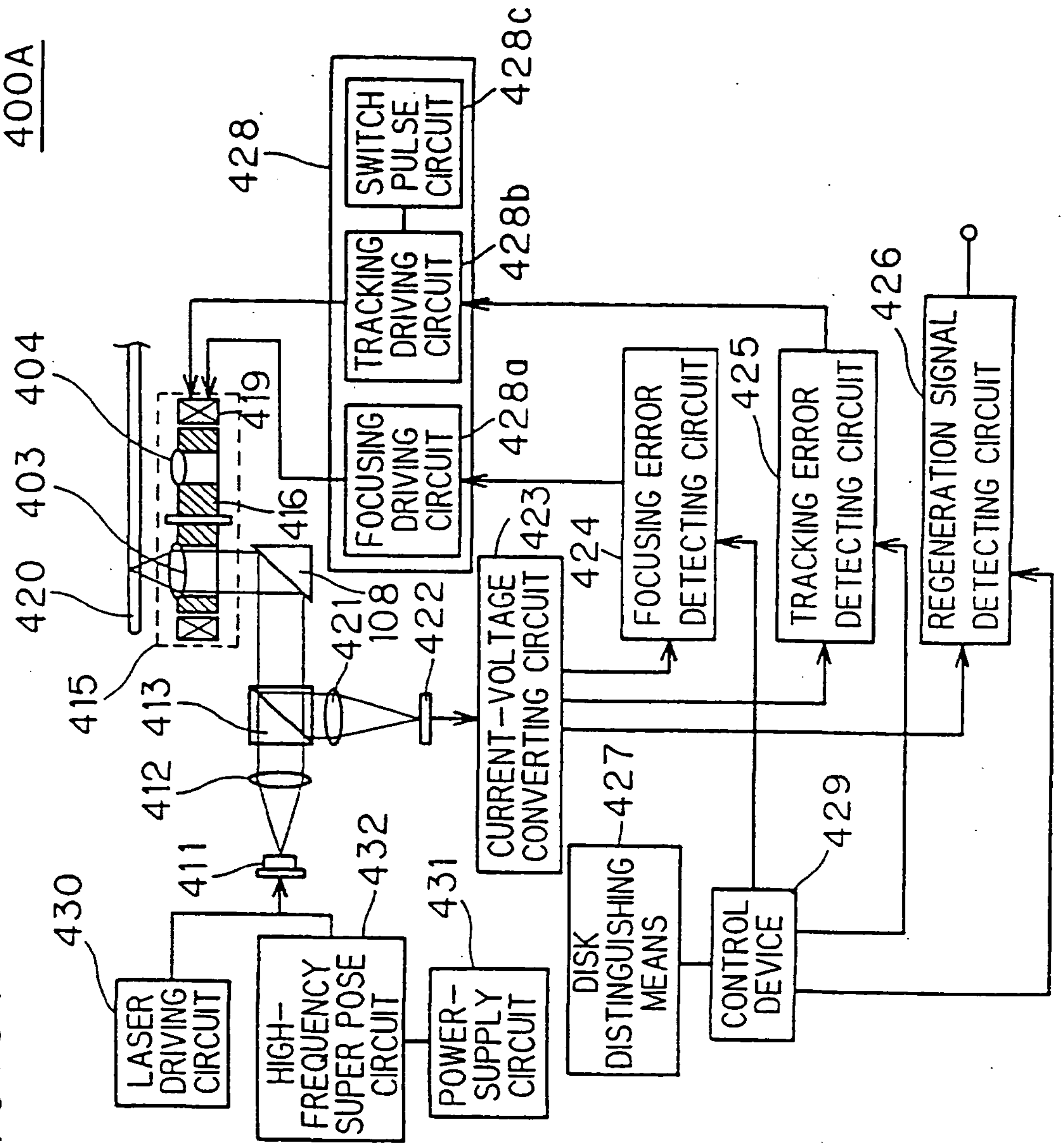


FIG.54


400A
428
SWITCH PULSE CIRCUIT
428c
TRACKING DRIVING CIRCUIT
428b
FOCUSING DRIVING CIRCUIT
428a
404
403
420
419
416
108
415
413
421
422
423
CURRENT-VOLTAGE CONVERTING CIRCUIT
424
FOCUSING ERROR DETECTING CIRCUIT
425
TRACKING ERROR DETECTING CIRCUIT
426
REGENERATION SIGNAL DETECTING CIRCUIT
412
411
427
DISK DISTINGUISHING MEANS
429
CONTROL DEVICE
430
LASER DRIVING CIRCUIT
432
HIGH-FREQUENCY SUPER POSE CIRCUIT
431
POWER-SUPPLY CIRCUIT

F I G . 55

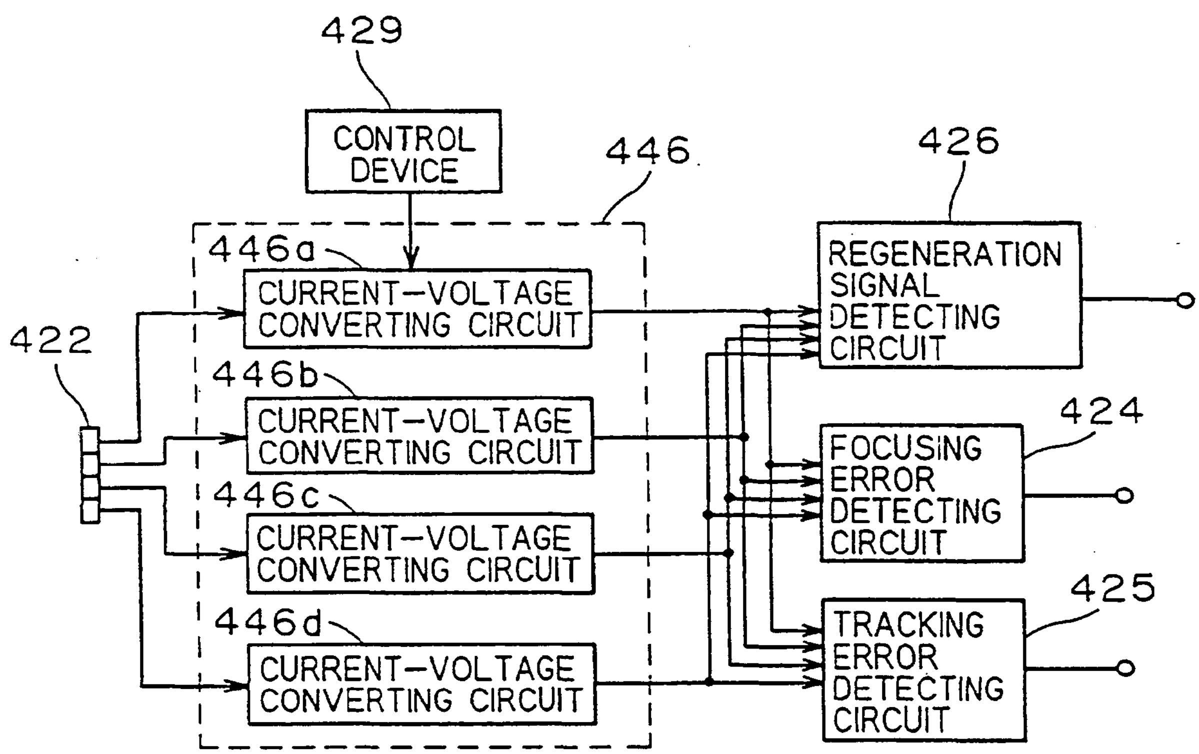

429
CONTROL DEVICE
446
446a
CURRENT-VOLTAGE CONVERTING CIRCUIT
446b
CURRENT-VOLTAGE CONVERTING CIRCUIT
446c
CURRENT-VOLTAGE CONVERTING CIRCUIT
446d
CURRENT-VOLTAGE CONVERTING CIRCUIT
422
426
REGENERATION SIGNAL DETECTING CIRCUIT
424
FOCUSING ERROR DETECTING CIRCUIT
425
TRACKING ERROR DETECTING CIRCUIT

FIG.56(A)

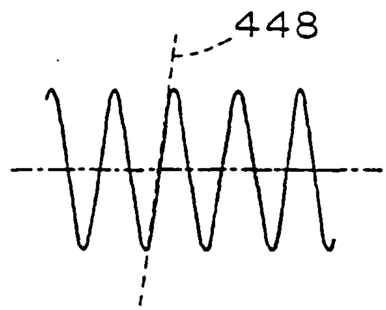


FIG.56(B)

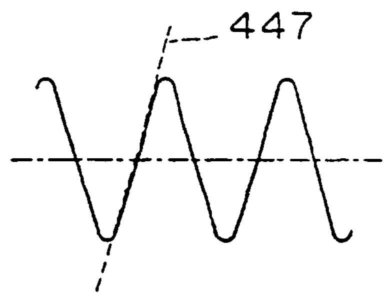


FIG.56(C)

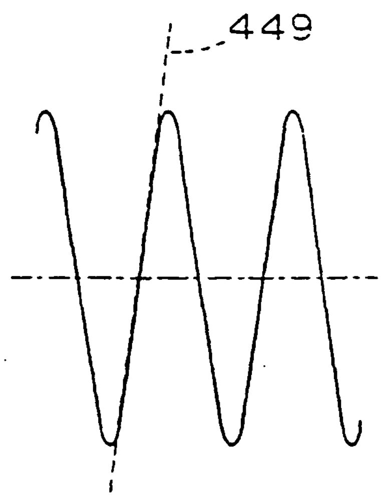


FIG. 57

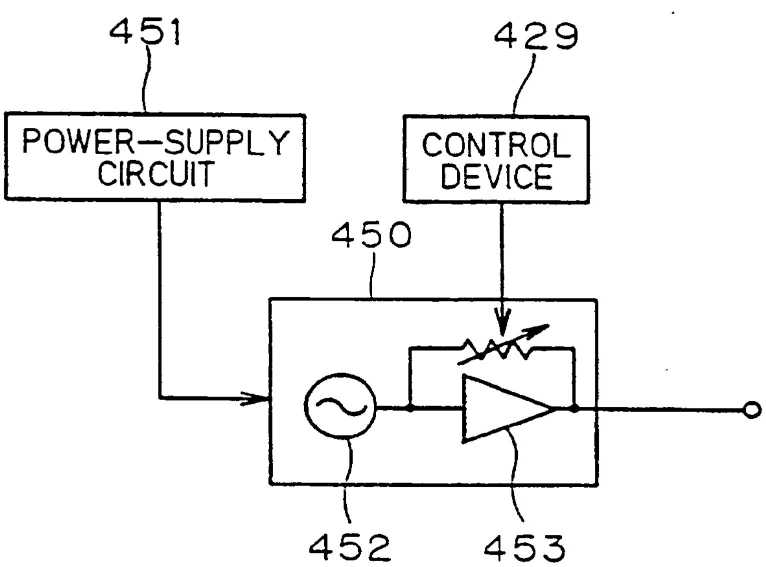
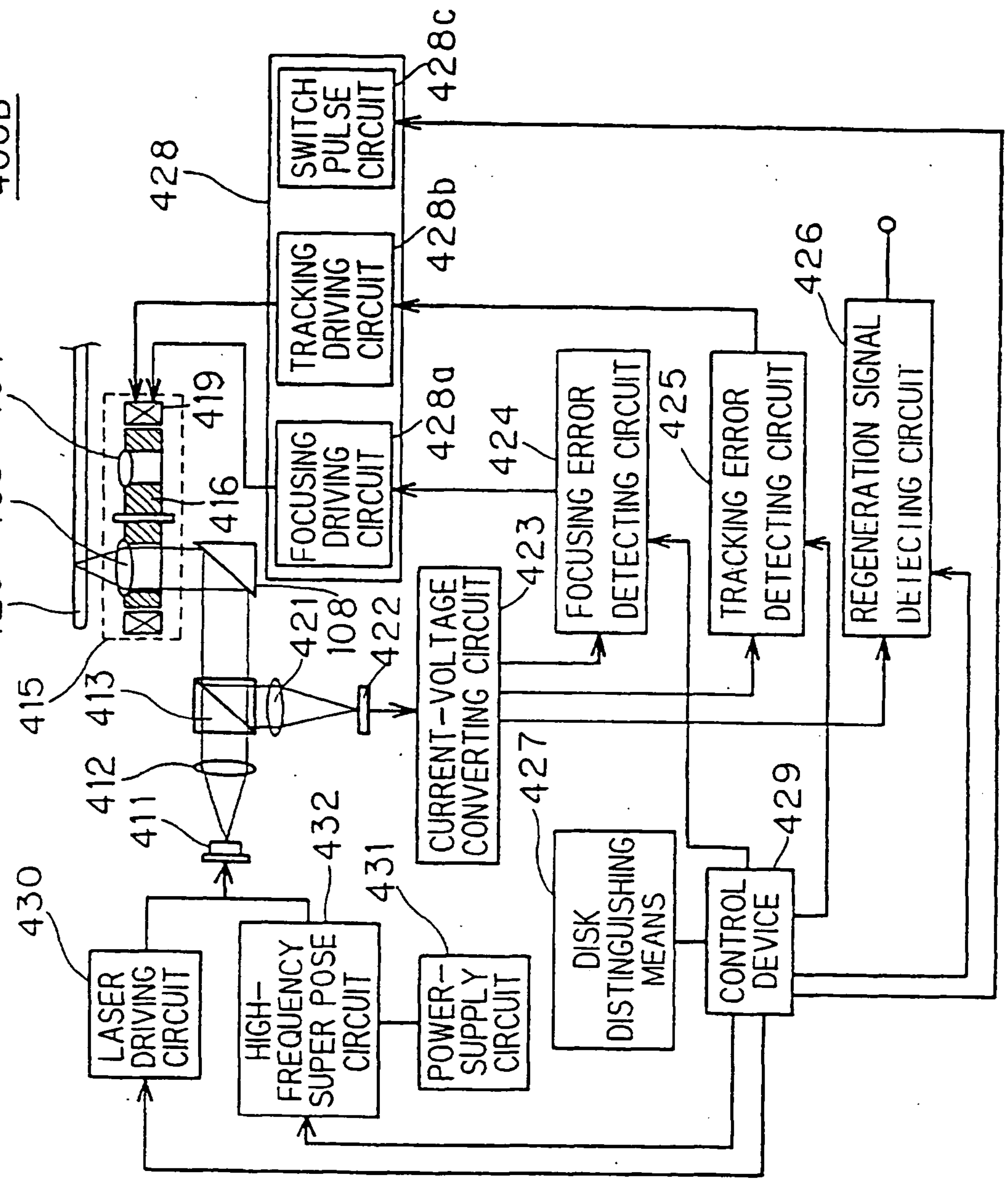


FIG. 58


400B
LASER DRIVING CIRCUIT
HIGH-FREQUENCY SUPER POSE CIRCUIT
POWER-SUPPLY CIRCUIT
DISK DISTINGUISHING MEANS
CONTROL DEVICE
CURRENT-VOLTAGE CONVERTING CIRCUIT
FOCUSING ERROR DETECTING CIRCUIT
TRACKING ERROR DETECTING CIRCUIT
REGENERATION SIGNAL DETECTING CIRCUIT
FOCUSING DRIVING CIRCUIT
TRACKING DRIVING CIRCUIT
SWITCH PULSE CIRCUIT
404
403
420
415
413
412
411
430
432
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427
429
423
421
108
422
416
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424
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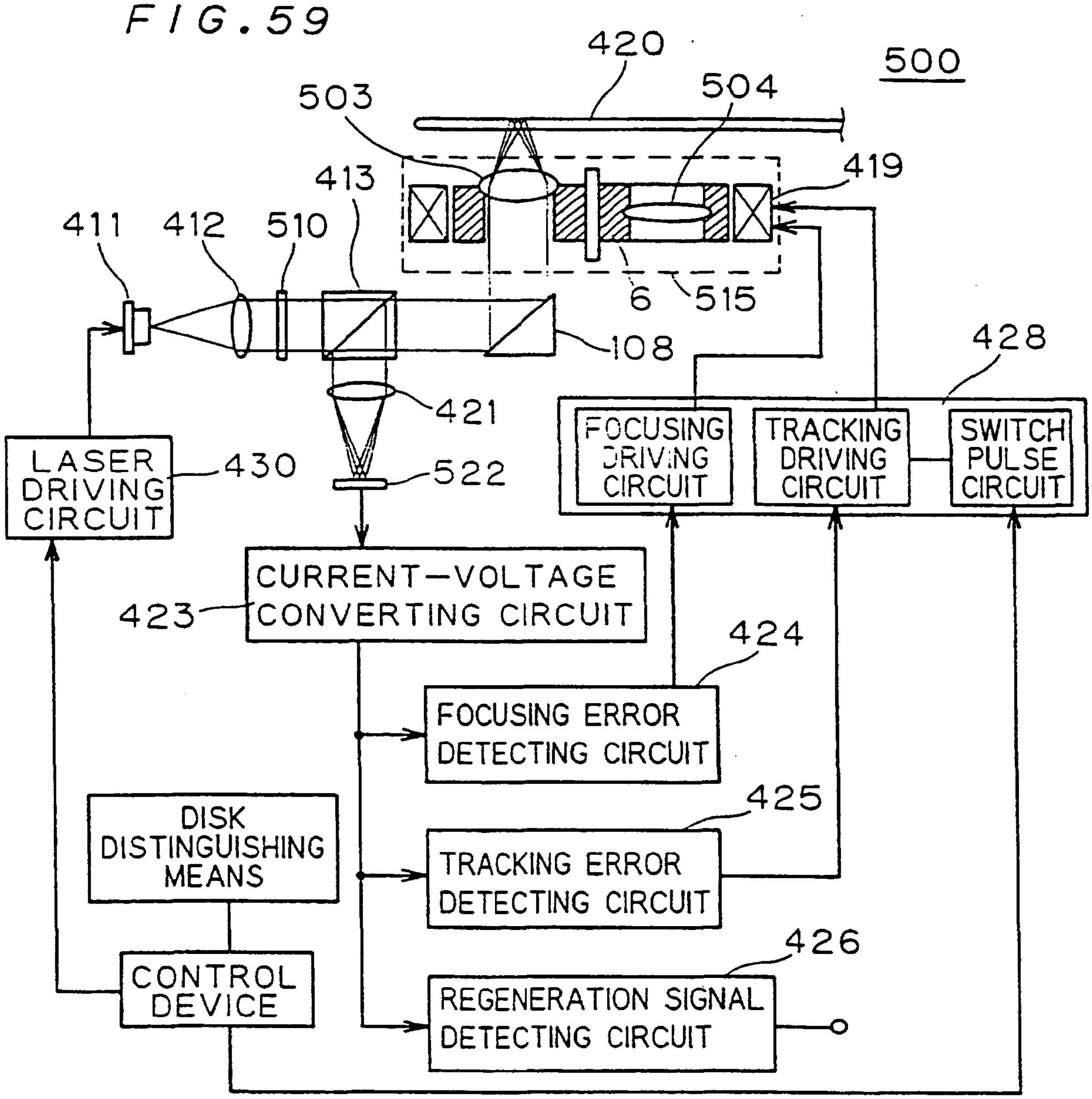
428
428a
428b
428c

FIG.59



420
500
503
504
413
419
411
412
510
6
515
108
428
421
FOCUSING DRIVING CIRCUIT
TRACKING DRIVING CIRCUIT
SWITCH PULSE CIRCUIT
LASER DRIVING CIRCUIT
430
522
CURRENT—VOLTAGE CONVERTING CIRCUIT
423
424
FOCUSING ERROR DETECTING CIRCUIT
425
DISK DISTINGUISHING MEANS
TRACKING ERROR DETECTING CIRCUIT
426
CONTROL DEVICE
REGENERATION SIGNAL DETECTING CIRCUIT

FIG. 60(a)

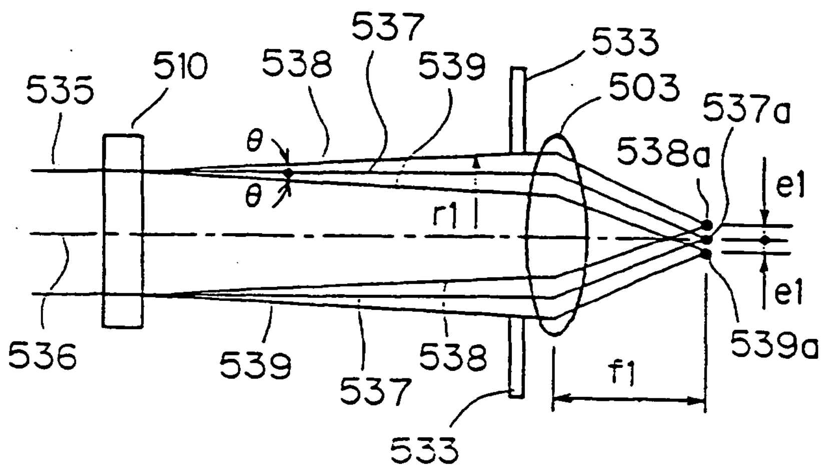


FIG. 60(b)

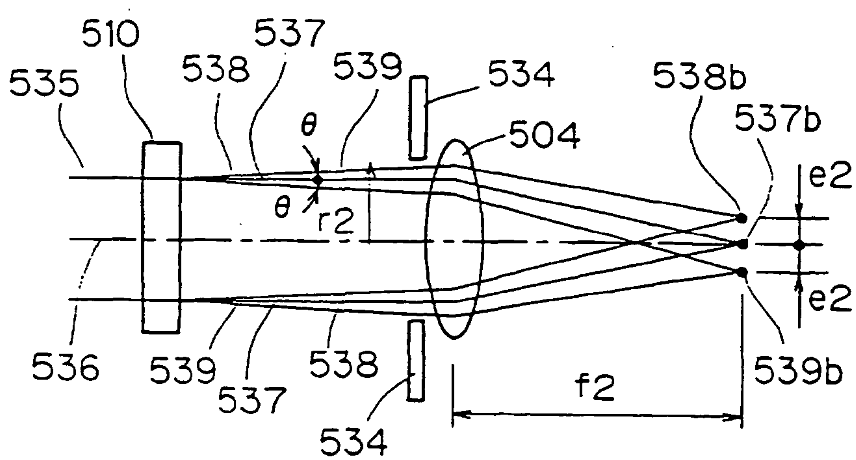


FIG. 61(a)

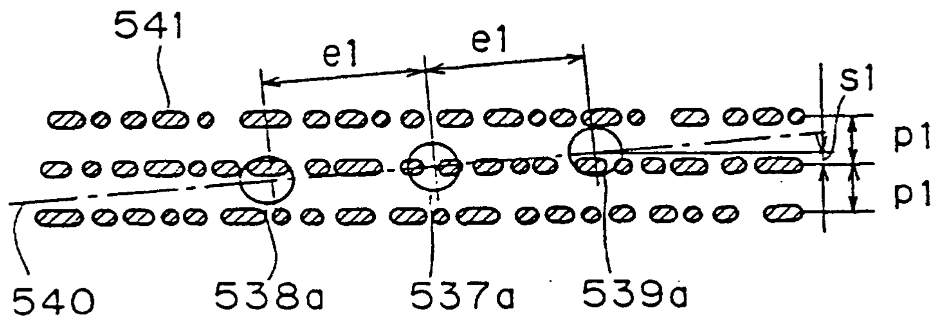


FIG. 61(b)

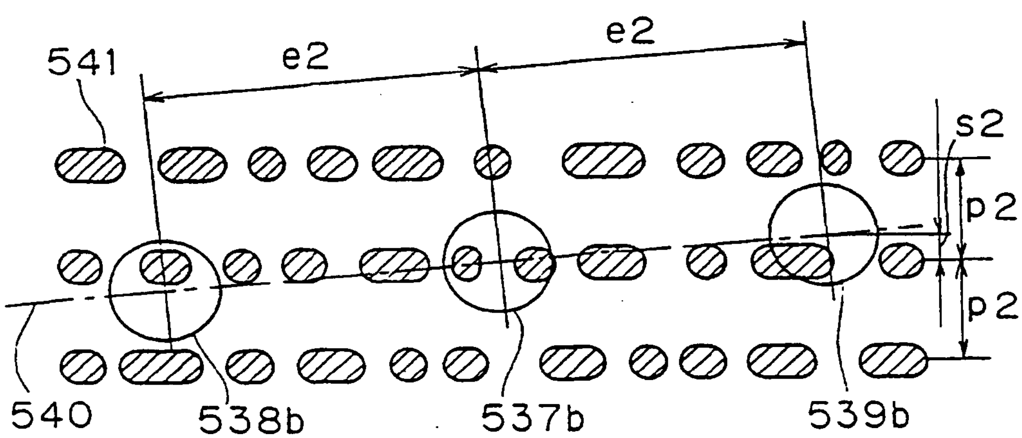


FIG. 62

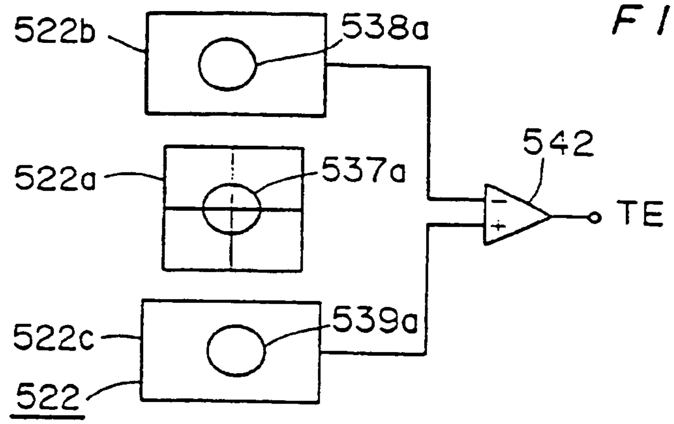


FIG. 63(a)

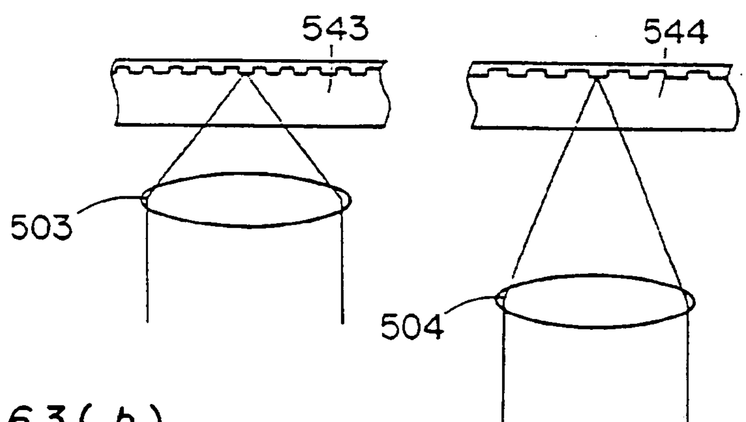
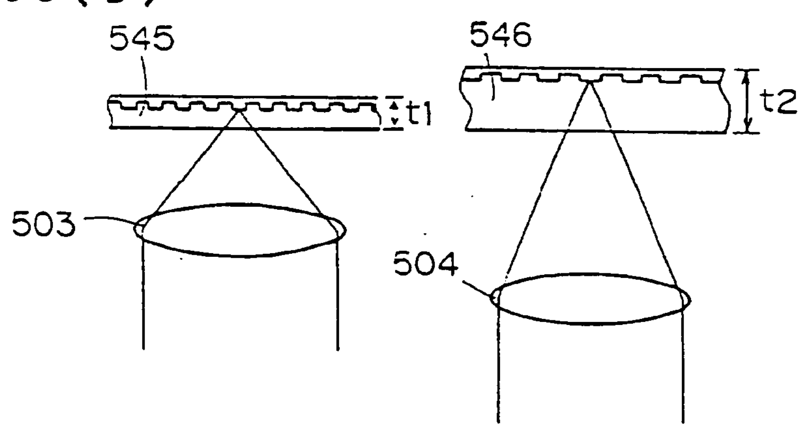
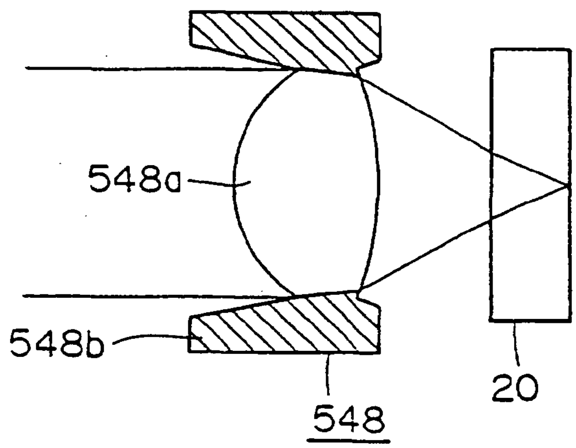


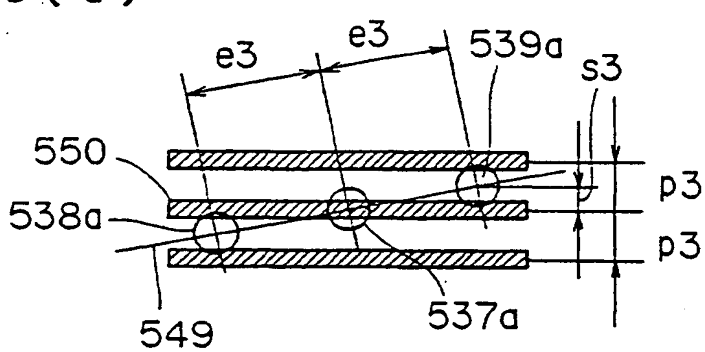
FIG. 63(b)



F I G. 64



F I G. 65 (a)



F I G. 65 (b)

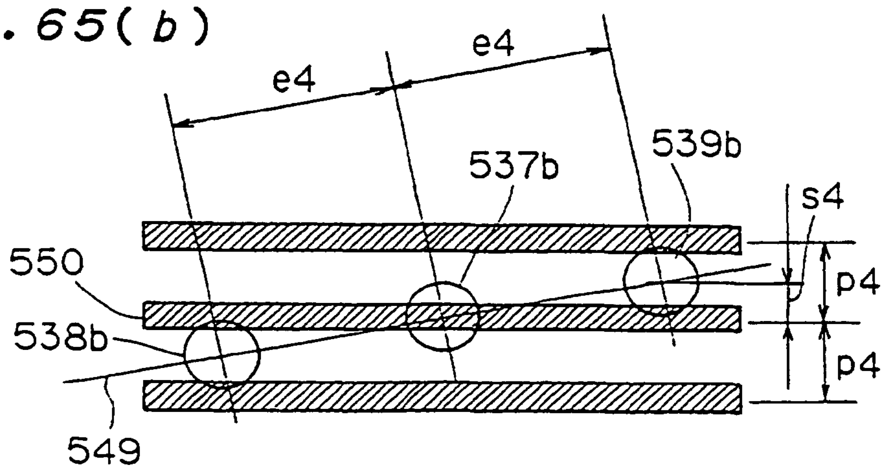


FIG. 66

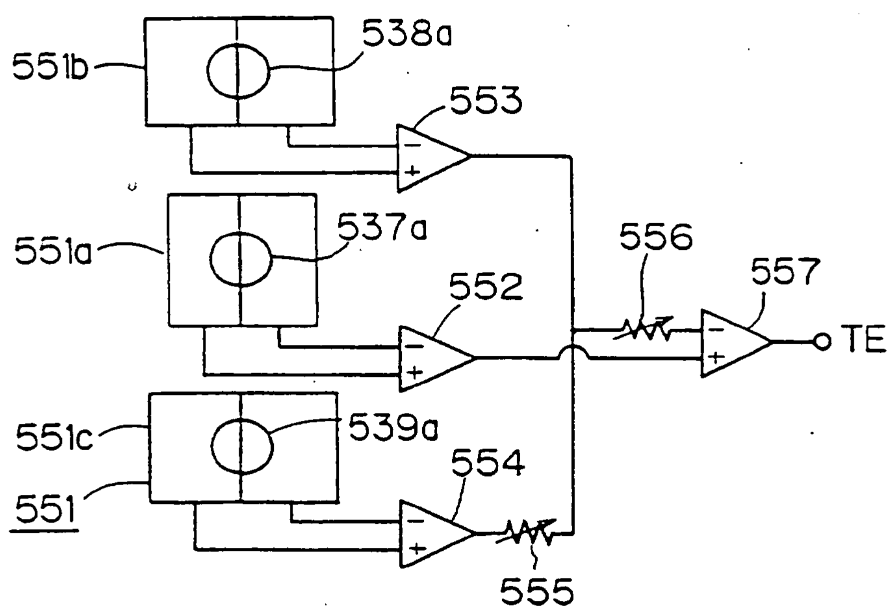


FIG. 67

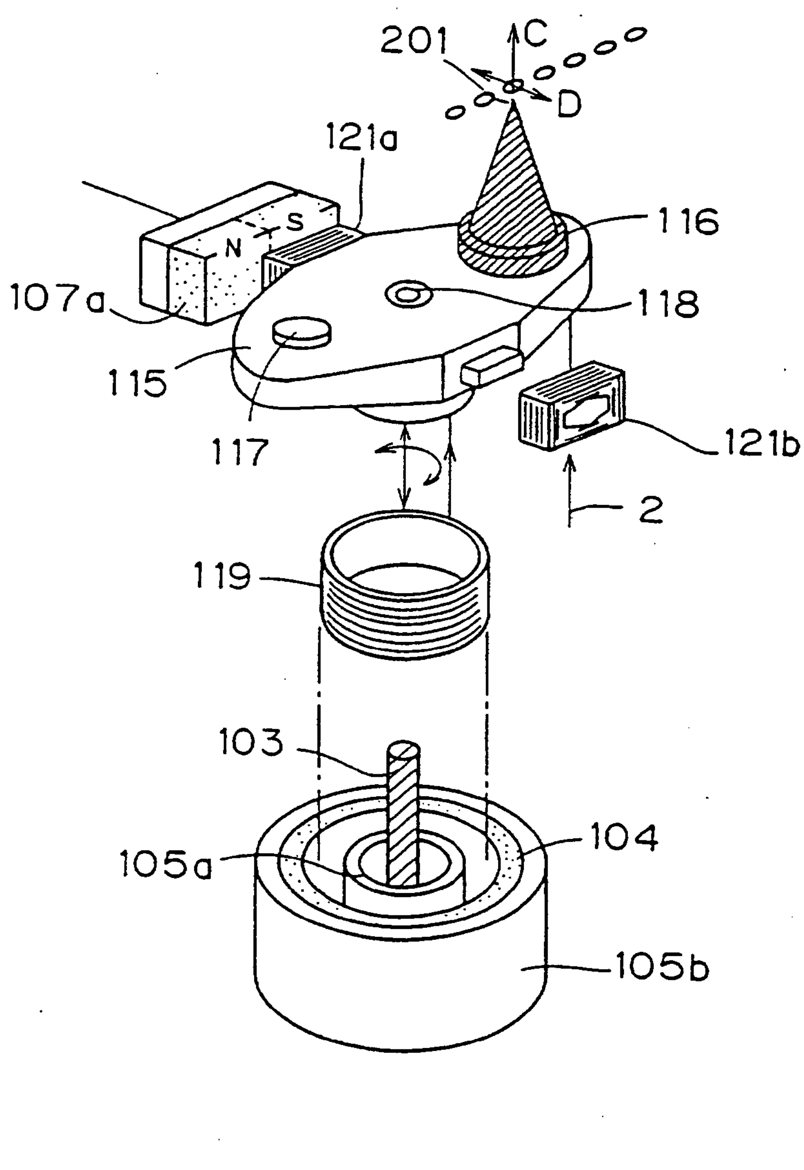


FIG.68

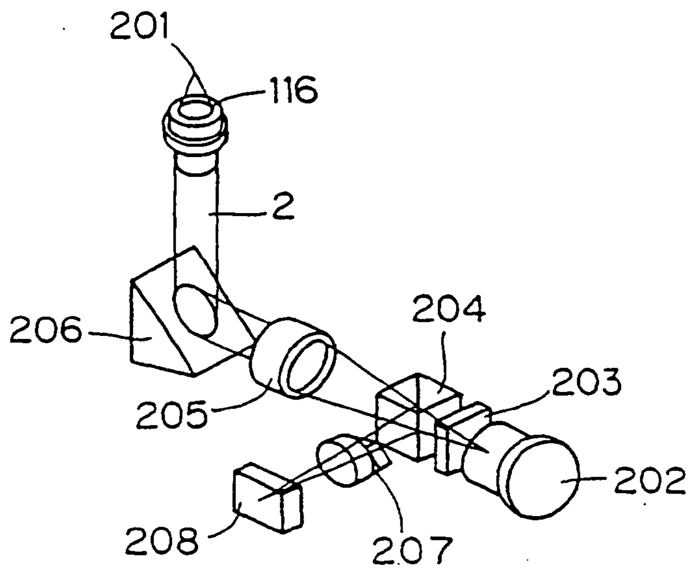


FIG.69

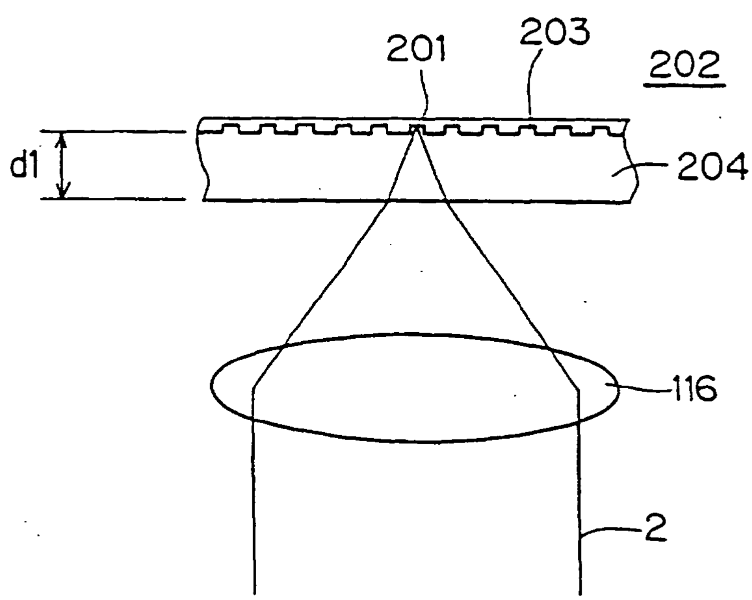


FIG.70

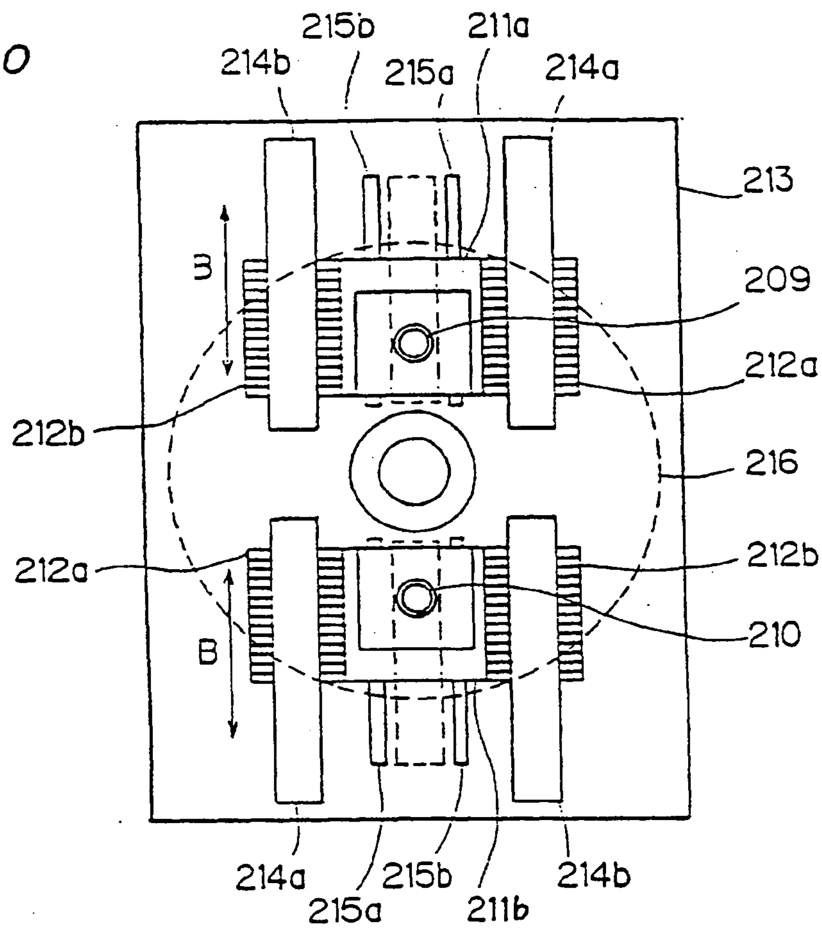

215b
211a
214b
215a
214a
213
B
209
212a
212b
216
212a
212b
210
B
214a
215b
214b
215a
211b

FIG.71

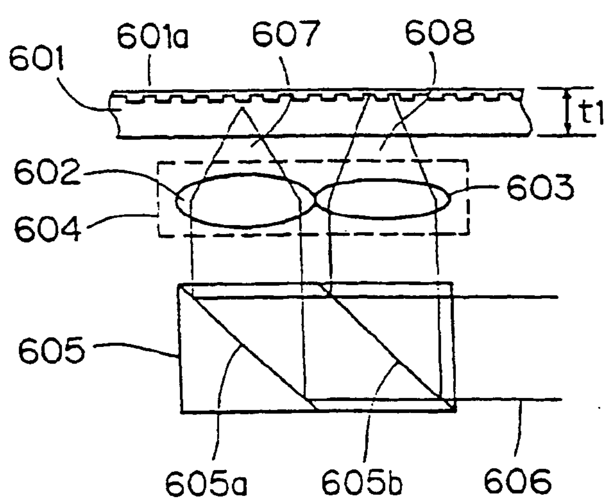

601
601a
607
608
t1
602
603
604
605
605a
605b
606

FIG. 72(a)

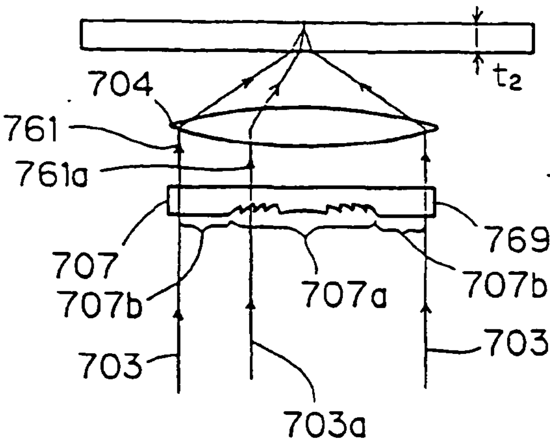


FIG. 72(b)

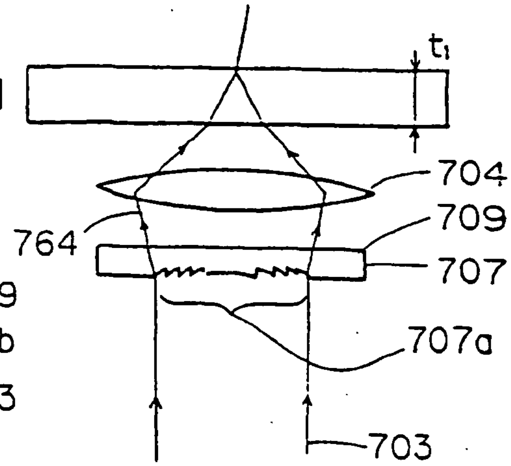
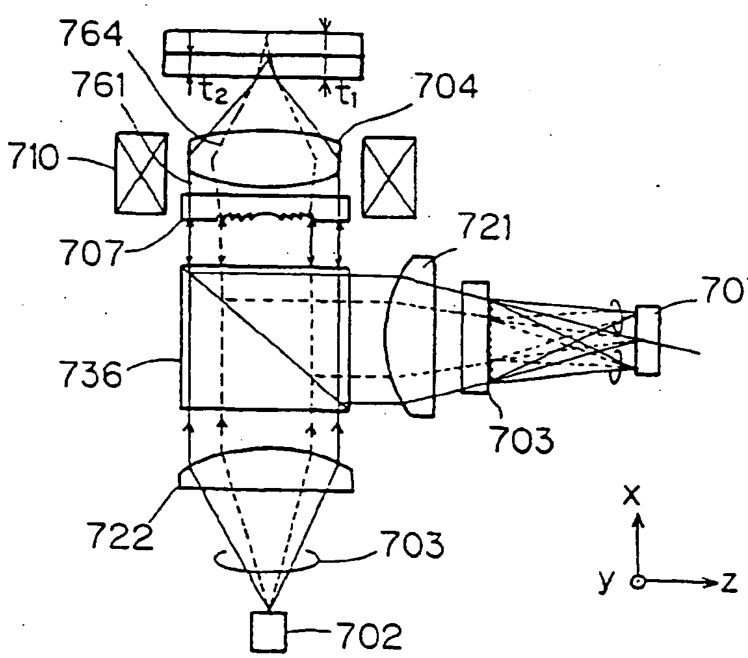


FIG. 73



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EUROPEAN SEARCH REPORT

Application Number
EP 01 10 3998

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	PATENT ABSTRACTS OF JAPAN vol. 95, no. 002 -& JP 07 037259 A (RICOH CO LTD), 7 February 1995 (1995-02-07) * abstract * * paragraph [0033] - paragraph [0039]; figure 5 *	1	G11B7/12 G11B7/135 G11B7/125 G11B7/09 G11B7/00
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	10 April 2001	Holubov, C

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10-04-2001

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